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ANNUAL REPORT

OF THE

WATER SUPPLY COMMISSION

OF

PENNSYLVANIA

1908

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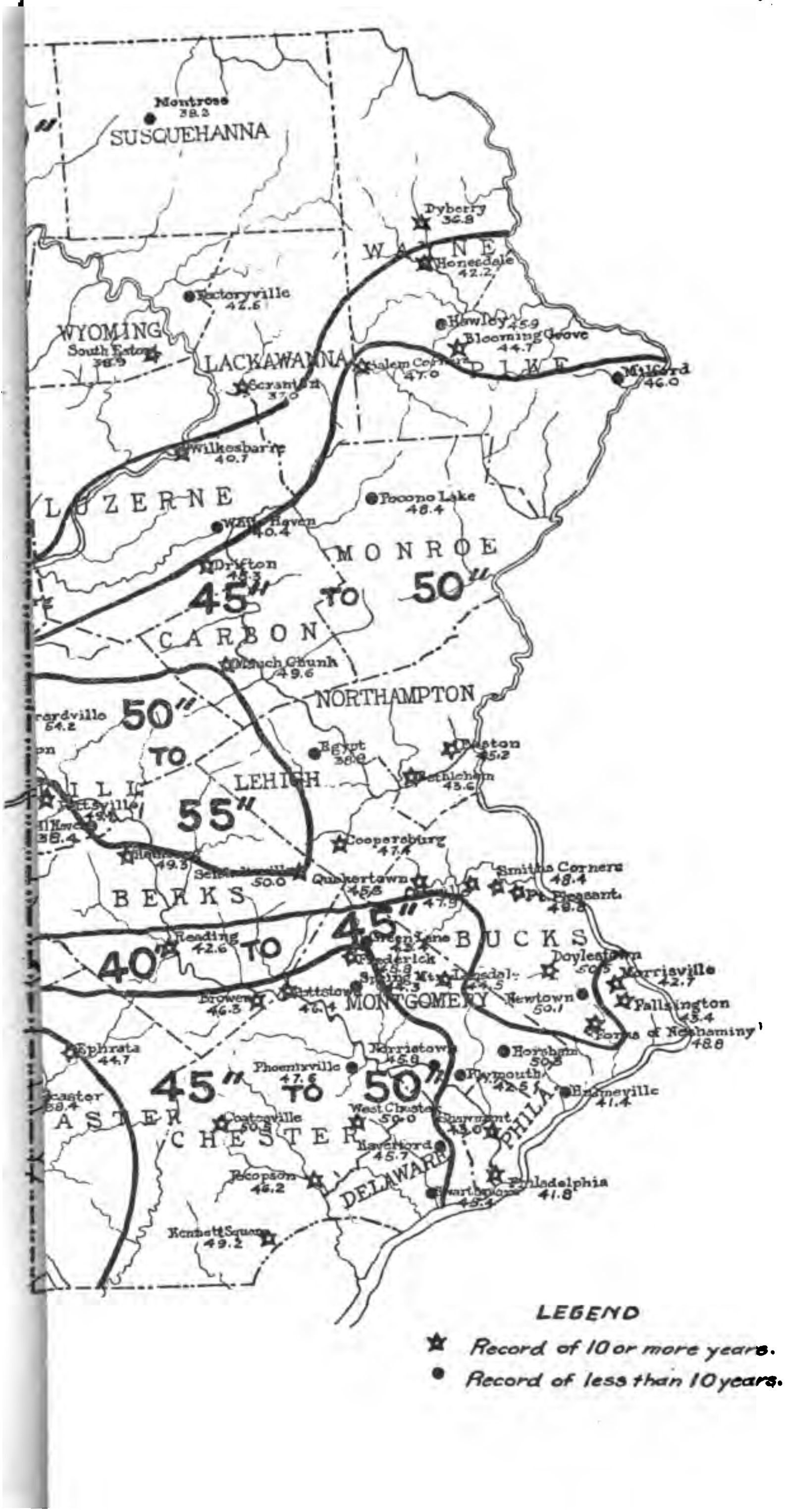
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Honesdale 42.2
Factoryville 42.6
Hawley 45.9
Blooming Grove 44.7
WYOMING
South Eaton 38.9
LACKAWANNA
Salem Corners 47.0
PIKE
Milford 46.0
Scranton 37.0
Wilkesbarre 40.7
LUZERNE
Pocono Lake 48.4
White Haven 40.4
MONROE
Drifton 48.3
45″ TO 50″
CARBON
Mauch Chunk 49.6
NORTHAMPTON
Girardville 54.2
50″ TO 55″
Egypt 38.8
Easton 45.2
Bethlehem 43.6
LEHIGH
Pottsville 49.6
Coopersburg 47.4
Smiths Corners 48.4
Pt. Pleasant 48.8
Seisholtzville 50.0
Quakertown 45.8
47.9
BERKS
45″ TO 40″
Reading 42.6
Green Lane
Frederick
Spring Mt.
Lansdale 44.5
BUCKS
Doylestown 50.5
Morrisville 42.7
Fallsington 45.4
Newtown 50.1
Brower 46.3
Pottstown 46.4
MONTGOMERY
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Ephrata 44.7
Norristown 45.8
Horsham 50.8
Phoenixville 47.6
Plymouth 42.5
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LANCASTER
Coatesville 50.5
West Chester 50.0
Holmesville 41.4
Haverford 45.7
PHILA.
CHESTER
Embreeville 46.2
DELAWARE
Philadelphia 41.8
Swarthmore 45.4
Kennett Square 49.2
LEGEND
★ Record of 10 or more years.
● Record of less than 10 years.

REPORT

OF THE

WATER SUPPLY COMMISSION

OF

PENNSYLVANIA.

1908.

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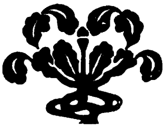

The Commission expresses its thanks to the various State Departments, the Hydrographic Branch of the United States Geological Survey, the United States Weather Bureau, and to municipal organizations, corporations and individuals who have supplied information embodied in this report.

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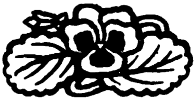


REPORT

OF THE

WATER SUPPLY COMMISSION OF PENNSYLVANIA.

Office of the Water Supply Commission,
Harrisburg, December 31st, 1908.

To the Honorable Edwin S. Stuart, Governor of the Commonwealth of Pennsylvania:

To the Members of the Senate and the House of Representatives of the Commonwealth of Pennsylvania:

In compliance with the provisions of the Act of the General Assembly approved May 4th, 1905, The Water Supply Commission of Pennsylvania respectfully submits its report for the year 1908.

During the year 17 applications for charters for water companies and 3 charters for water power companies were approved by the Commission, and letters patent thereon issued by the Governor, while 2 agreements of consolidation and merger by and between water companies previously created were similarly approved.

Under the Act of the General Assembly approved May 28th, 1907, providing that no obstruction shall be placed in or along any river or stream within the Commonwealth which has been declared public or navigable, 34 cases have been considered by the Commission, either upon application for its approval of the placing of an obstruction or upon complaint made to the Commission against the placing of an obstruction without its approval, of which cases 19 applications were approved. It has been the aim of the Commission to preserve the flood carrying capacity of the channel of the streams, and to reduce the amount of silt carried thereby, and it is gratified to report that the condition of the channels of some of the streams show improvement therein. The report of the Engineer of the Commission, upon the Causes of and Methods of Relief from Floods in Turtle Creek, which appears as an appendix to this report, details investigations authorized by the Commission in the endeavor to ascertain and assist in relieving the extreme conditions of restricted channel and flood overflow which occur periodically in that valley.

The system of stream gagings, inaugurated by the Commission in 1907, has been materially extended during the year, 20 new stations having been established. The total number now maintained is 50, while in addition to those maintained by the Commission, data from 23 additional stations is regularly received. A daily record of the volume of flow of the streams at these stations is obtained and tabulated, and the Commission expects to publish these data during the coming year. In the meantime the records are in the office of the Commission for the use of those requiring such information.

In the fall of 1907 the Commission undertook the systematic examination of every water supply and water power system, private or incorporated, in the Commonwealth, in order that complete data might be at hand when considering applications for proposed new companies, and in order that it might have thorough knowledge of the condition of the water supplies of the State. This work covers the inspection by an employe of the Commission of each water supply system, and the preparation of maps of each county on which the systems are plotted on a scale of one mile to the inch. Detailed reports upon each county, describing the condition of the principal streams, towns and their water supplies are then prepared. The status of all unused charters is also examined, and it is expected that this work will be completed before the end of the year 1909.

Special endeavor was made to obtain specific information concerning flood and drought conditions in the State, both during the high water periods of the winter and spring and during the extraordinary drought of the summer and fall, and the data obtained have been compiled in Chapters 4 and 5 of this report. Other subjects which the Commission has studied during this period, concerning which it feels that the public should be informed, are discussed in detail.

Respectfully submitted,

JOHN BIRKINBINE,
Chairman.

HENRY M. BRACKENRIDGE,
Vice-Chairman.

THOMAS J. LYNCH,
Secretary.

ROBERT S. CONKLIN,
Commissioner of Forestry.

SAMUEL G. DIXON,
Commissioner of Health.

CHAPTER I.

INACTIVE WATER COMPANIES.

The status of water and water power companies which have been regularly incorporaed and granted franchises, but which have wholly failed to do the things for which the franchises were granted, or to perform the public duties imposed upon them by the grant from the State, has engaged the attention of the Commission. One of the objects for which this Commission was formed was that of conserving the water resources of the State, by preventing, as far as possible, the improvident granting of charters where there did not appear to be a bona fide intention on the part of the incorporators to put them to use, and the consequent tieing-up, unused, of this valuable resource of the State; and if this is so it is equally important that the State reclaim those franchises which have heretofore been granted, which never having been used, should revert to the State that they may be re-granted, when there is need for their use.

That it was the intention of the framers of the general law for the formation and regulation of corporations, that rights granted to corporations should not be allowed to remain unused in the hands of the grantee, is evident. The Act of April 17th, 1876, amending the original Corporation Act of April 29th, 1874, provides in Section 11, as follows:

> "If any company incorporated under this act, or the act to which this is a supplement, shall not proceed to carry on its work and construct its necessary buildings, structures and improvements within the space of two years from the date of its letters patent, and shall not within the space of five years thereafter complete the same, the rights and privileges thereby granted to said corporation shall revert to the Commonwealth."

This provision was subsequently amended by the Act of May 16th, 1889, which re-enacted the above quoted provision, and added the proviso that any corporation which had failed to complete its work within the time prescribed may, by application to the Court of Common Pleas of the county wherein it is situated, secure additional time.

Prior to this amendment, however, the Legislature passed a new and distinct provision on the subject, Section 5 of the Act of June 13th, 1883, providing that "any corporation of the second class, created under the provisions of the act to which this is a supplement, or any of its suplements, that shall not within two years from the date of its letters patent in good faith organize and do the things contemplated by its charter and have paid up at least one-fourth of its capital stock, shall be held and deemed to have forfeited its charter, and the Attorney General shall, on application of any citizen, take the proper legal steps to forfeit and vacate its said charter."

The reading of these statutory provisions makes it evident that, in the minds of the legislators, a franchise granted by the State and unused for a period of two years should revert to the State and not be allowed to remain, much less be compelled to remain, in the hands of the grantees. If this is the proper view to take of unused franchises for corporations in general, formed under the Act of April 29th, 1874, and its supplements, it ought unquestionably to be the proper view with which to regard corporations formed with power to grasp and hold rights in water, a resource which the State seeks to conserve.

The apparently clear intention of the Legislature, as expressed in the above quoted statutes, however, does not furnish an equally clear solution of the question of the status of such corporations, because of their conflicting provisions, as well as of the conflicting constructions placed upon them by the courts as to the effect of their operation; and also because of the apparently antagonistic legislation intended to prevent corporations escaping their supposed duty to pay taxes for the full period of their existence. Thus it is provided by Section 32 of the Act of June 1st, 1889, that "no corporation......made taxable by this act, shall hereafter be dissolved by the decree of any court of Common Pleas, nor shall any judicial sale be valid or a distribution of the proceeds thereof made, until all taxes due the Commonwealth have been fully paid into the State Treasury, and the certificate of the Auditor General, State Treasurer and Attorney General to this effect filed in the proper court, with a proceeding for dissolution or sale."

It is true, of course, that the above quoted provisions of the Acts of 1876, 1889 and 1883 would seem to terminate the existence of a corporation at the end of two years from the date of its incorporation, if the provisions of said acts have not been complied with, and that, therefore, a petition for dissolution would not be necessary; but while this may be the proper construction of the law there is at present no method by which such delinquent corporations can be placed on record as being out of existence. At the same time the provisions of the said Act of 1876, as amended by the Act of 1889, seem to differ materially from those of the Act of 1883, the former declaring that for failure to commence the work within two years from the date of its incorporation, or to complete the same within five years thereafter, the franchise becomes forfeited, the corporation being ipso facto dissolved, and the latter providing that before the corporation becomes dissolved and the franchise reverts to the State, proceedings against it must be instituted by the Attorney General for that purpose. In consquence of these conflicting provisions of the statutory law, conflicting decisions have been reached by the courts. Thus it has been held by the Supreme Court of Pennsylvania, in Commonwealth vs. Lykens Water Company, 110 Pa. 391, that where a charter had been granted to a water company and it had wholly failed to do anything within two years from the date of its letters patent "all its rights and privileges had reverted to the Commonwealth........The limitation of time," say the court, "inheres in the very grant under which the latters patent issue. It is an expressed clause in a contract under which the corporation was created and its charter accepted........When the legislature reserves the right to repeal a charter on the happening of a certain event, it may enact the repeal whenever the event happens without first invoking the judgment of the court. The Act of 1876 did not specifically require any action of the legislature to cause the franchises granted to revert to the Commonwealth; as, then, after the expiration of two years, nothing had been done under the charter to continue its life, all its franchises in equity reverted to the Commonwealth."

This decision was rendered on October 5th, 1885, and, therefore, after the passage of the Act of June 13th, 1883, which seems to provide for such forfeiture only upon proceedings by the Attorney General; yet notwithstanding this fact it was subsequently held by the Court of Common Pleas of Dauphin County in Lebanon Water Company's Petition, 4 Dauph. 228, that before a forfeiture of the charter of a water company, created under the Act of April 29th, 1874, occurs, there must be action by the Attorney General, as provided by the Act of June 13th, 1883.

There is, therefore, under the law, as it exists at present, uncertainty as to whether a water company, which has been granted a charter, but which has wholly failed to do anything within two years from the date of the granting thereof, but against which a judgment of ouster has not been rendered by the courts, has ceased to exist as a corporation; and whether its franchise has, by virtue thereof, reverted to the State.

In addition to what should be the general policy of the State in reclaiming unused water francihses, it is often highly important for the Commission, in passing upon an application for a charter, to consider whether a former charter granted for the same territory, often with an exclusive fanchise, and usually with the right of eminent domain, has life, or whether it has reverted to the Commonwealth.

For these reasons, in accordance with the provisions of Section 3 of the Act of May 4th, 1905, creating this Commission, authorizing and requiring the Commissioners "to procure all data and facts necessary to advise them thoroughly of the situation of the water supply of the State," the Commission has undertaken to ascertain all cases where charters hertofore granted have reverted, or should revert to the Commonwealth for failure to comply with the provisions of the above quoted acts of 1876, 1883 and 1889 with regard to the commencement or completion of their necessary works, but against which no decree of forfeiture or dissolution has been entered.

As a result of these investigations it has been found that in many of the cases where the provisions of the above quoted acts have not been complied with, and particularly in cases where work has not been commenced, or no business has ever been done within two years from the date of the incorporation, the grantees of such charters are desirous of surrendering them to the state, but are prevented from doing so in the manner prescribed by law unless taxes are paid on their capital stock for the two years or more that they have been in existence, on account of the requirements of the above quoted provision of the Act of June 1st, 1889; but this such corporations are, as a rule, unwilling to do, having done no business and made no money. Under these conditions, many such companies desirous of surrendering their franchises, but unwilling to pay their back taxes, which would enable them to procure a decree of dissolution, have filed in the office of the Auditor General a statement, under oath, of the facts, asking to be stricken form the records of that department. To date 197 of such petitions or affidavits have been filed in that department, 153 of which state in general that no organization was effected, no business done or no work of construction of their necessary buildings, works or structures commenced within two years from the date of their letters patent; and 44 of which in general state that the construction of their necessary works, buildings and structures was not completed within five years thereafter, or that at the time of the filing of such petition or affidavit they were doing no business and intended to do no business in the future, and were without property assets or indebtedness.

Table No. 1 and No. 2 give a complete list of such corporations, together with the class to which each belongs, the district which it was authorized to supply and the date of incorporation. In designating the class to which each company belongs, the figures 1, 2 and 3 are used; 1 being "for the supply of water to the public," 2 being "for the supply, storage and transportation of water and water power for commercial and manufacturing purposes," and 3 being for those companies formed under paragraph 18 of Section 2 of the Act of April 29th, 1874, denominated in general as "for the storage, transportation and furnishing of water for manufacturing and other purposes, and for the creation, establishing, furnishing, transmission and using of water power therefrom." In several cases the charters state the purpose to be "for the supply of water to the public, and for the supply, storage and transportation of water and water power for commercial and manufacturing purposes." In such cases the company is stated to belong to both classes 1 and 2.

It will be noted that of these companies 126 in table No. 1 and 37 in table No. 2, or a total of 163, belong to class No. 1, for the supply of water to the public; 13 in table No. 1 and 5 in table No. 2, a total of 18, belong to class 2; while 11 in table No. 1 and 1 in table No. 2, a total of 12, belong to both classes 1 and 2; and but 4 of them, 3 in table No. 1, and 1 in table No. 2, belong to Class 3.

TABLE NO. 1.

Water and water-power companies which have filed a davits that no organization was effected, no business was done or no work of construction of their necessary buildings, works or structures commenced within two years from the date of their Letters Patent.

Name.	Class.	District.	Date of Incorporation.
Allen Water Co.,	1	Allen township, Washington county,	Oct. 25, 1897.
American Spring Water Co.,	2	Lampeter township, Lancaster county,	Aug. 22, 1902.
Amity Water Co.,	1 & 2	Mifflin township, Allegheny county,	Nov. 26, 1900.
Annville Water Company, No. 2,	1	Annville, Lebanon conuty,	Sept. 23, 1889.
Altman Water Co.,	1	Black Lick township, Indiana county,	April 24, 1903.
Armagh Water Power Company,	2	Armagh township, Mifflin county,	Aug. 26, 1901.
Askam Water Company,	1	Warrier Run, Luzerne county,	Jan. 29, 1896.
Baldwin Water Co.,	1	Baldwin township, Allegheny county,	March 9, 1899.
Beechmont Water Co.,	1 & 2		May 17, 1901.
Bessemer Water Co.,	1	Masontown, Fayette county,	Oct. 30, 1901.
Blaidsdall Water Company (The),	1	Bradford township, McKean county,	Feb. 26, 1892.
Blue Mountain Water Supply Co.,	2	Smithfield township, Monroe county,	Sept. 28, 1900.
Borough Water Co.,	3	Montrose, Susquehanna county,	Sept. 24, 1889.
Borough Water Co.,	1	Rochester, Beaver county,	April 8, 1890.
Branch Water Co., (Into which was merged the Penn Run Water Company),	1	Cherry Hill township, Indiana county,	March 18, 1903.
Bridgeville Water Co.,	1 & 2	Upper St. Clair, Allegheny county,	Nov. 26, 1900.
Buckwha Water Storage & Supply Co.,	1	Lower Towamensing township, Carbon county,	Dec. 17, 1901.
Burrell Township Water Co.,	2	Burrell township, Indiana county,	April 2, 1903.
Cocalico Water Co.,	1	Ephrata township, Lancaster county,	Jan. 28, 1892.
California Water Co.,	1	California, Washington county,	Sept. 26, 1894.
Camp Hill Water Co.,	1	Camp Hill, Cumberland county,	April 15, 1895.
Camp Hill Springs Water Co. (a),	1	Camp Hill, Cumberland county,	Oct. 19, 1897.
Cannonsburg Water Co.,	1	Cannonsburg, Washington Co.,	Nov. 13, 1894.
Canton Township Water Co.,	1	Canton township, Washington county,	March 7, 1901.

(a) Two years had not elapsed when affidavit was filed, but since has.

TABLE NO. 1—Continued.

Name.	Class.	District.	Date of Incorporation.
Carrick Water Co.,	1 & 2	Baldwin township, Allegheny county,	Nov. 26, 1900.
Centre Water Co.,	1	Centre township, Columbia county,	Nov. 18, 1902.
Citizens Water Co. of Frackville, Pa.,	1	Frackville, Schuylkill county,	May 26, 1902.
Clinton Water Co.,	1	Pine Creek township, Clinton county,	Nov. 8, 1901.
Cold Stream Water Co. (a),	1	Phillipsburg, Centre county,	July 6, 1896.
College Hill Water Co.,	1	College Hill, Beaver county,	Jan. 13, 1897.
Colonia Water Co.,	1	Moon township, Beaver county,	Oct. 22, 1901.
Confluence Water Co.,	1	Confluence, Somerset county,	May 18, 1903.
Conoy Water & Power Company,	2	Conoy township, Lancaster county,	July 17, 1896.
Core Creek Water Power Co.,	2	Yardley, Bucks county,	Jan. 28. 1901.
Cove Creek Water Co.,	2	Penn township, Perry county,	April 14, 1905.
Crystals Springs Water Co.,	1	Austin, Potter county,	May 5, 1893.
Crystal Water Co.,	2		April 24,1893.
Darby Water Co.,	1	Darby, Delaware county,	—— — 1887.
Dauphin Water Co.,	1	Dauphin, Dauphin county,	Feb. 29, 1892.
Deep Creek Water Company (c),	1	Mt. Carmel, Northumberland county,	Nov. 8, 1895.
Duncannon Water Co.,	1	Duncannon, Perry county,	Sept. 24, 1891.
East Harrisburg Water Company,	1	East End, Vil., Swatara township, Dauphin county,	April 15, 1895.
Easttown Water Co.,	1	Easttown township, Chester county,	—— — 1887.
Economy Water Co.,	1	Harmony township, Beaver county.	June 4, 1902.
Edge Hill Water Co.,	1	Springfield township, Montgomery county,	Dec. 24, 1894.
Edgeworth Extension Water Co.,	1	Sewickley, Ohio & Franklin townships, Allegheny county,	Aug. 6, 1900.
Elliott Water Co.,	1	Elliott, Allegheny county,	June 24, 1895.
Enterprise Water Co. of Delaware County,	1	Upper Darby township, Delaware county,	Aug. 6, 1901.
Esplen Water Co.,	1	Esplen, Allegheny county,	June 24, 1895.
Fairchance Water Co.,	1	Fairchance, Fayette county,	May 26, 1893.
Fairmount Water Co.,	1	Red Bank township, Clarion county,	Nov. 19, 1901.
Fairview Spring Water Co.,	1	Palmer township, Northampton county,	May 2, 1900.
Falling Springs Water Co. (b),	1	March township, Luzerne county,	June 25, 1894.
Fayette City Water Co.,	1	Fayette City, Fayette county,	Nov. 15, 1897.
Finleyville Water Company,	1	Finleyville, Washington county,	March, 9, 1903.
Florence Water Co. (c),	1	New Florence, Westmoreland county,	April 1, 1901.
Forest Water Co.,	1 & 2	Croyle township, Cambria county,	Aug. 27, 1901.
Forward Township Water Co.,	1	Forward township, Allegheny county,	Aug. 6, 1902.
Frackville Water Company,	1 & 2		July 22, 1901.
Franklin Extended Water Co.,	1	Franklin Extended, Cambria county,	Feb. 28, 1902.
Galeton Water Co.,	1	Galeton, Potter county,	Jan. 3, 1899.
George's Water Company (b),	1	George's township, Fayette county,	Dec. 5, 1904.
German Township Water Co. (b),	1	German township, Fayette county,	Dec. 5, 1904.
Glen Cairn Water Co.,	1	Allegheny township, Westmoreland county,	Feb. 6, 1901.
Griffin Water Supply Company,	2	Nicholson township, Fayette county,	Oct. 30, 1901.
Groveton Water Co.,	1	Robinson township, Allegheny county,	June 24, 1903.
Homestead Borough Water Co.,	1	Homestead, Allegheny county,	Oct. 15, 1903.
Homestead Water Co.,	1	Homestead, Allegheny county,	April 23, 1889.
Idlewood Water Co.,	1	Chartiers township, Allegheny county,	July 10, 1895
Ingleside Water Co.,	1	Allegheny township, Westmoreland county,	Dec. 23, 1892.
Keystone Water Co.,	1	Harrisburg, Dauphin county,	Feb. 29, 1892.

(a) Two years had not elapsed when affidavit was filed, but since has.
(b) Information under oath contained in tax report.
(c) Information contained in letter to Auditor General.
(d) Affidavit filed by Borough Solicitor.

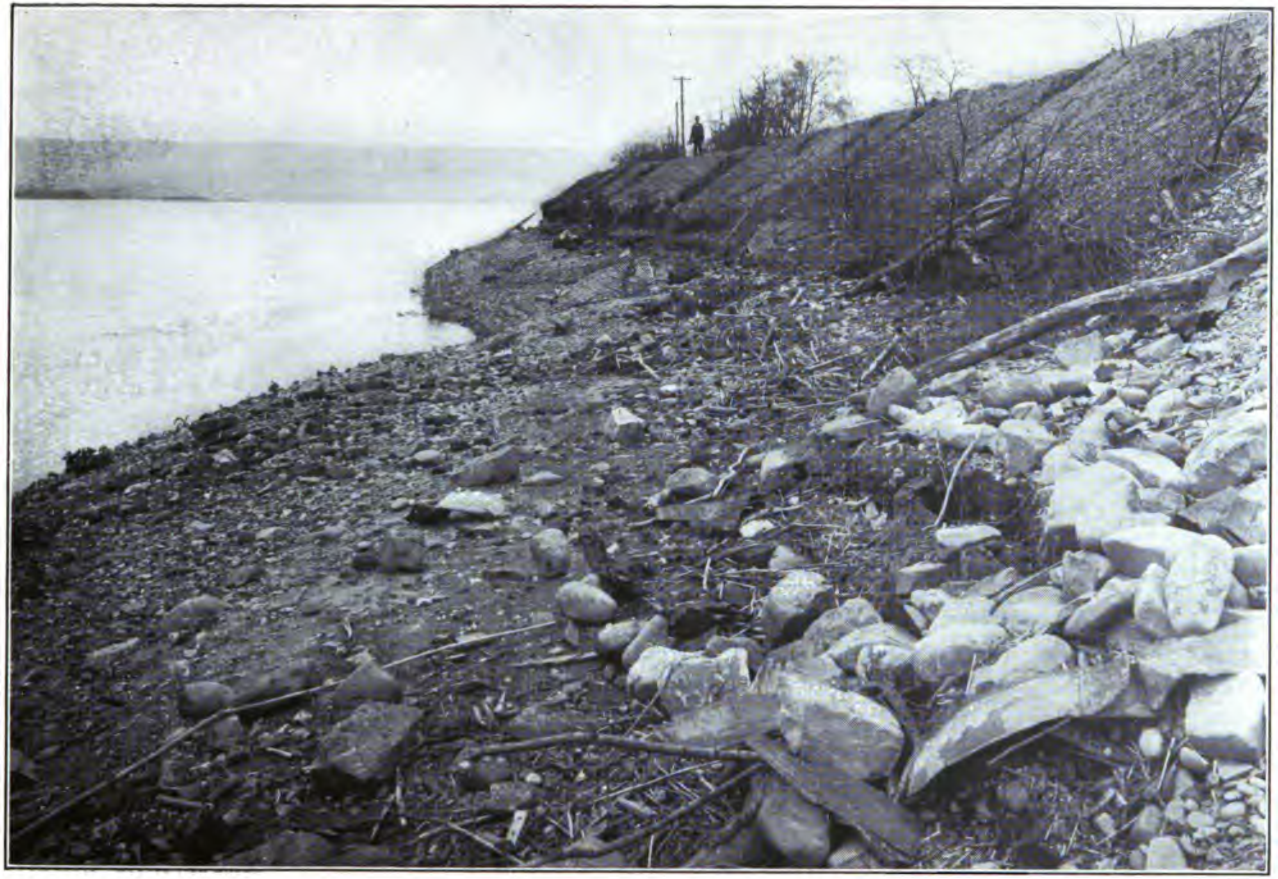
TABLE NO. 1—Continued.

Name.	Class.	District.	Date of incorporation.
Keystone Water Co. of Milton, Pa.,	1	Milton, Northumberland county.	Sept. 28, 1900.
Laurelton Water Co.,	1	Laurelton, Hartley township, Union county,	Aug. 23, 1897.
Logston Water Co.,	1	Aliquippa, Beaver county,	Nov. 25, 1901.
Manor Water Co.,	1	Manor township, Armstrong county,	May 13, 1898.
Mansfield Valley Water Co.,	1	Mansfield Valley, Allegheny county,	March 15, 1887.
Maple Forrest Water Supply Co.,	2	Middle Smithfield township, Monroe county,	Sept. 28, 1900.
Marietta Water Co.,	1	Marietta, Lancaster county,	May 27, 1892.
Marple Water Co. of Delaware Co.,	1	Marple township, Delaware county,	Aug. 6, 1901.
Masontown Water Co.,	2	Masontown, Fayette county,	June 18, 1900.
Masontown Water Supply Co. (a),	3		July 12, 1906.
McKees Rocks Water Co.,	1	McKees Rocks, Allegheny county,	Oct. 29, 1903.
Melboy Water Co.,	1	Hastings, Cambria county,	Aug. 31, 1904.
Mifflin Water Co.,	1	Mifflin township, Allegheny county,	Nov. 30, 1894.
Mine Spring Water Co.,	1	Bridgeton, Bucks county,	Feb. 19, 1896.
Monoca Water Co.,	1	Phillipsburg, Beaver ounty,	Aug. 12, 1892.
Montgomery & Bucks County Water Co.,	1	Montgomery and Bucks counties,	March 28, 1900.
Mountain View Water Company,	1	Steelton, Dauphin county,	Aug. 16, 1904.
Mountain Water Co. of Luzerne Co.,	1	Pittston, Luzerne county,	Dec. 24, 1886.
Maylan Water Co.,	1	Conemaugh township, Indiana county,	April 24, 1903.
Munhall Borough Water Co.,	1	Munhall, Allegheny county,	Oct. 15, 1903.
Nottingham Water Co.,	1	Nottingham township, Washington county,	March 9, 1903.
New Philadelphia Water Company,	1	New Philadelphia, Schuylkill county,	July 21, 1902.
Newport Water Co.,	1	Newport, Perry county,	Dec. 22, 1890.
Oak Grove Water Co.,	1	Pine Creek township, Clinton county,	July 1, 1901.
Oakdale Water Co.,	1	Oakdale, Allegheny county,	July 25, 1902.
Octorado Water Company (The),	1	Salsburg, Chester county,	April 23, 1890.
Oliver Water Co.,	1	Duquesne, Allegheny county,	Nov. 30, 1894.
Ontario Water Co.,	1	Bridgeville, Allegheny county,	May 20, 1904.
Panther Water Co.,	1	Washington township, Jefferson county,	April 27, 1903.
Peerless Water Co.,	1	Sewickley, Westmoreland county,	Aug. 31, 1893.
Peoples Water Company (The),	1	Tredyffrin township, Chester county,	1887.
People's Water Co., of Coraopolis, Pa.,	1	Coraopolis, Allegheny county,	Dec. 20, 1895.
Peoples Water Co. of Wilkes-Barre, Pa.,	1	Wilkes-Barre, Luzerne county,	May 19, 1891.
Peoples Water & Power Co. of Red Lion, Pa.,	1 & 2	Red Lion, York county,	Feb. 6, 1900.
Peoples Water Storage & Supply Co.,	1 & 2	Greene township, Pike county,	Jan. 25, 1901.
Peters Water Co.,	1	Peters township, Washington county,	March 9, 1903.
Philadelphia Water & Filter Co.,	1	Philadelphia, Philadelphia county,	May 7, 1896.
Pine Grove Water Co. of Schuylkill Co.,	1	Pine Grove, Schuylkill county,	1887.
Portland Water & Power Co.,	3	Northampton county,	Feb. 9, 1904.
Provident Water Co.,	1	Rochester, Beaver county,	April 4, 1899.
Pure Water Supply Company,	2	White Deer township, Union county,	May 18, 1900.
Pure Water Supply & Transportation Co.,	1 & 2	Philadelphia, Philadelphia county,	July 12, 1899.
Racoon Water Co.,	1	Aliquippa, Beaver county,	Dec. 9, 1901.
Ridley Township Water Co.,	1	Ridley township, Delaware county,	Nov. 18, 1890.
Rittersville Water Co.,	1	Hanover township, Lehigh county,	July 12, 1899.
Rockville Water Co.,	1	Harrisburg, Dauphin county,	May 28, 1898.
Rostraver Water Co.,	1	Rostraver township, Westmoreland county,	July 28, 1902.
Saltsburg Water Co.,	1	Saltsburg, Indiana county,	Jan. 3, 1889.

TABLE NO. 1—Continued.

Name.	Class.	District.	Date of incorporation.
Scotia Water Co.,	1 & 2	Jefferson township, Allegheny county,	Nov. 26, 1900.
Sheraden Water Co.,	1	Sheraden, Allegheny county,	June 24, 1895.
Shinglehouse Water Co.,	1	Shinglehouse, Potter county,	May 13, 1902.
Shippensburg Water Co.,	1	Shippensburg, Cumberland county,	1885.
Silver Springs Water Co. (c),	1	Mechanicsburg, Cumberland county,	April 23, 1895.
Slaters Water Co. of East Bangor,	1	East Bangor, Northampton county,	July 17, 1899.
Snowden Water Co.,	1 & 2	Upper St. Clare township, Allegheny county,	Nov. 26, 1900.
Solomon Run Water Co.,	1		Oct. 28, 1901.
Souderton Water Co.,	1	Souderton, Montgomery county,	Oct. 11, 1895.
South Buffalo Water Co.,	1	South Buffalo township, Armstrong county,	July 14, 1898.
South Side Spring Water Co.,	1	Palmer township, Northampton county,	Oct. 31, 1896.
Speers Water Co.,	1	Speers, Washington county,	Oct. 25, 1897.
Spring Water Co., of Hopbottom,	1	Hopbottom, Susquehanna county,	Nov. 9, 1899.
Steelton Water Co.,	1	Steelton, Dauphin county,	Feb. 29, 1892.
Susquehanna Water Co. (The),	1	Plains township, Luzerne county,	Jan. 4, 1893.
Swatara Water Co.,	1	Swatara and Lower Swatara townships, Dauphin county,	Oct. 11, 1898.
Taxpayers Water Co.,	1	Carlisle, Cumberland county,	June 16, 1899.
Throop Water Co. (The), (a),	1	Dickson City, Lackawanna county,	Nov. 25, 1892.
Union Township Water Co.,	1	Union township, Washington county,	March 9, 1903.
Upper Merion Water Company,	1	Upper Merion township, Montgomery county,	1887.
Valley Supply Water Co.,	1	Carbondale, Lackawanna county,	Aug. 11, 1887.
Vanport Water Co.,	1	Borough township, Beaver county,	Feb. 26, 1902.
Wallenpaupack Water Co.,	1	Hawley, Wayne county,	Oct. 15, 1897.
Watersburg Water Co.,	2	Menallen township, Fayette county,	Nov. 18, 1903.
West Easton Water Co.,	1	West Easton, Northampton county,	May 2, 1900.
West Homestead Water Co.,	1	West Homestead, Allegheny county,	Oct. 15, 1903.
West Milton Water Co.,	1	Kelly township, Union county,	Sept. 28, 1900.
West Newton Water Co.,	1	West Newton, Westmoreland county,	Jan. 19, 1898.
West Side Water Co. (c),	1	Allen township, Washington county,	Nov. 21, 1899.
White Marsh Water Co.,	1	White Marsh township, Montgomery county,	Dec. 24, 1894.
Whitney Water Co.,	1	Unity township, Westmoreland county,	Feb. 7, 1898.
Williamsburg Water Co.,	1	Williamsburg, Blair county,	Dec. 19, 1895.
Woods Water Co.,	1	Crafton, Allegheny county,	July 1, 1895.
Youngsville Borough Water Co.,	1	Youngsville, Warren county,	July 15, 1889.

(a) Two years had not elapsed when affidavit was filed, but since has.
(c) Information contained in letter to Auditor General.



Susquehanna river bank at Harrisburg—Showing effect of a 16.5 ft. flood.

TABLE NO. 2.

Water and water-power companies which have filed affidavits that they have failed to complete the construction of their necessary works, buildings and structures, or that they were at the time of filing of the affidavit doing no business and did not intend to do business in the future, and were without property, assets or indebtedness.

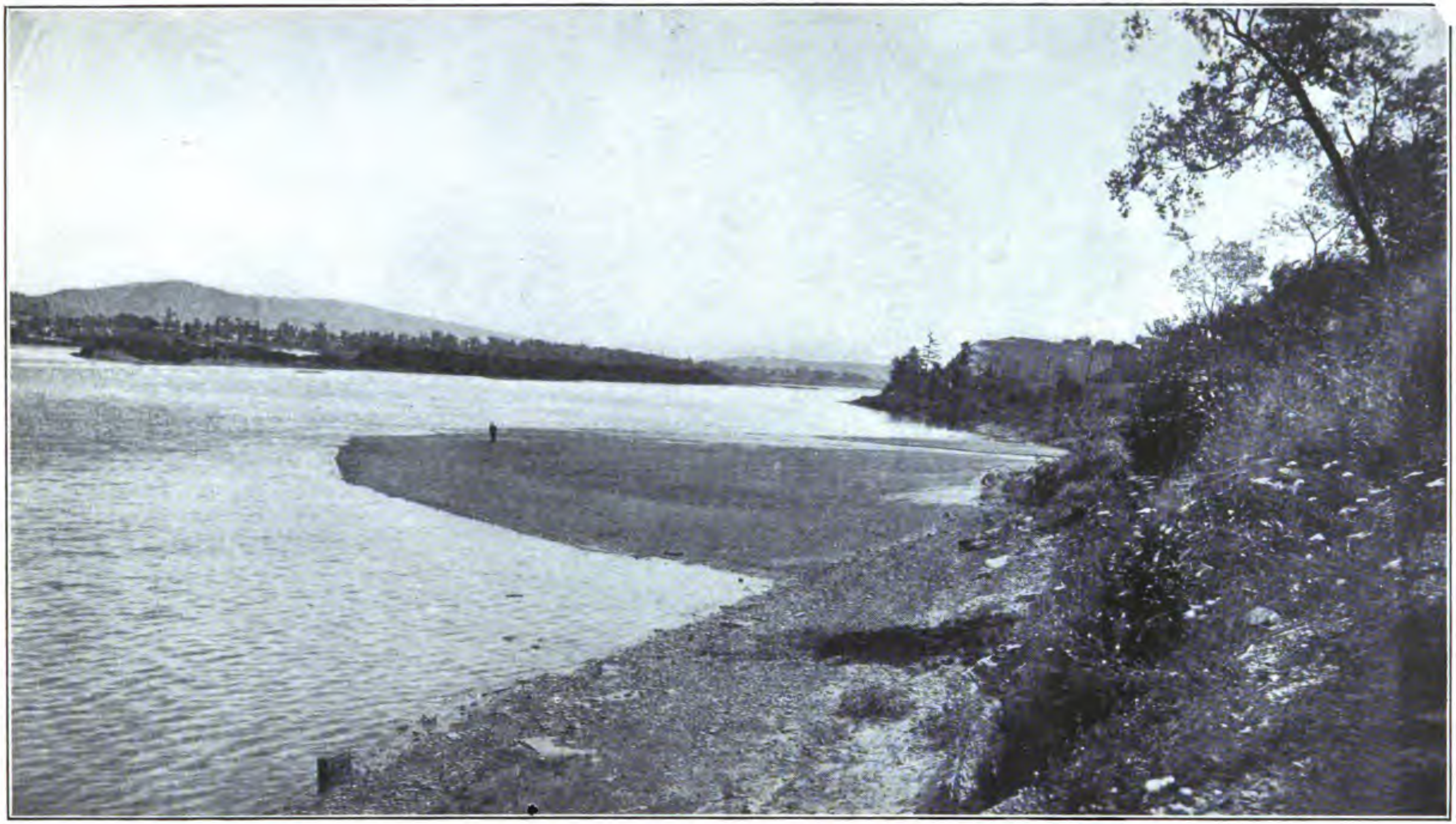
Name.	Class.	District.	Date of Incorporation.
Alliquippa Water Co.,	1	Alliquippa, Beaver county,	Aug. 12, 1901.
Baden Water Co.,	1	Baden, Beaver county,	March 31, 1902.
Bolivar Water Co.,	1	Boliver, Westmoreland county,	Aug. 10, 1887.
Chester Creek Water Co.,	1	Middletown township, Delaware county,	July 16, 1902.
Chester Creek Pure Water Co.,	1	Aston township, Delaware county,	July 16, 1902.
Coraopolis Water Company (The),	1	Coraopolis, Allegheny county,	March 3, 1890.
Deven Water Co.,	1	Easttown township, Chester county,	April 13, 1893.
Duquesne Water Co.,	1	Duquesne, Allegheny county,	June 17, 1892.
Elm Water Co.,	1	Lower Merion township, Montgomery county,	April 13, 1893.
Fairfield Water Co.,	1	Fairfield township, Westmoreland county,	Aug. 10, 1887.
Falls Creek Water Company,	1	Falls Creek, Clearfield county,	Nov. 12, 1894.
Granite Water Co. (The),	1	Butler township, Schuylkill county,	July 12, 1892.
Haverford Water Co.,	1	Haverford township, Delaware county,	Jan. 4, 1886.
Haverford Water Co.,	3		Nov. 4, 1886.
Irwin Water Co.,	1	Irwin, Westmoreland county,	Nov. 3, 1883.
Keystone Water Co.,	1	Plains township, Luzerne county,	Oct. 15, 1888.
Lackawaxen Water Power Co.,	2	Pike county,	May 21, 1901.
Lower Merion Water Co.,	1	Lower Merion township, Montgomery county,	June 4, 1886.
Matamoras Water Co.,	1	Westfall township, Pike county,	May 24, 1898.
Mauch Chunk Water Power Co.,	2	Carbon county,	April 22, 1901.
Midway Water Co. (a),	1	Midway, Washington county,	Nov. 26, 1904.
Mill Hall Water Co.,	1	Lamar township, Clinton county,	June 27, 1898.
Millbrooks Water Co.,	1	Pittston township, Luzerne county,	Oct. 22, 1888.
Millbrook Water Co.,	1	Haverford township, Delaware county,	April 13, 1893.
Miners Mills Water Company,	1	Miners Mills, Luzerne county,	Dec. 23, 1890.
Mount Pocono Water Company,	1	Pocono, Monroe county,	March 8, 1895.
Neville Island Water Company,	1	Neville township, Allegheny county,	March 29, 1894.
Paupack Water Co.,	1 & 2	Wayne county,	Nov. 27, 1899.
Peltzonia Water Co.,	1	Stewardson township, Potter county,	June 11, 1901.
Peoples Power & Water Company,	2	Fairview township, York county,	June 6, 1900.
Radnor Water Co.,	1	Radnor township, Delaware county,	Jan. 4, 1886.
Rush Township Water Company,	1	Rush township, Centre county,	June 27, 1901.
Schuylkill Water Co.,	1	Philadelphia,	Sept. 10, 1889.
Skippack Water Co.,	1	Lower Providence township, Montgomery county,	April 13, 1893.
St. Clair Water Company (The),	1	St. Clair township, Allegheny county,	June 27, 1892.
St. Davids Water Co.,	1	Radnor township, Delaware county,	April 13, 1893.
Stafford Water Co.,	1	Tredyffin township, Chester county,	April 13, 1893.
Susquehanna Water Co. (The),	1		Sept. 14, 1885.
Valley Forge Water Co.,	1	Upper Merion township, Montgomery county,	April 13, 1893.
Valley View Water Co.,	1	Valley View, Schuylkill county,	1883.
Warrior Run Water Co.,	1	Warrior Run, Luzerne county,	Jan. 16, 1896.
West Susquehanna Water Power Company,	2	Clearfield county,	April 29, 1901.
Wyoming Borough Water Co.,	1	Wyoming, Luzerne county,	1887.
Yellow Creek Water Power Co.,	2	Bedford county,	July 20, 1900.

(a) Information contained in letter to Auditor General.

The above tables include only those companies which have placed themselves on record as being out of existence and have expressed a desire to have their charters revert to the State. Many other companies, however, which have failed to commence business or to begin or complete their work within the time required by law, have done nothing in the way of declaring their intention to abandon the enterprises and forfeit their charters, and many of these charters are being held for speculative purposes. The Commission has undertaken to determine the facts with regard to such companies by counties, but at this time the work is not complete. Of the 67 counties in the State the records of 43 are complete, and these show that out of a total of 995 water and water power companies incorporated prior to the creation of this Commission, only 581, or 58.4 per cent. were found to be in actual existence, and 414, or 41.6 per cent. have not done or are not now doing business.

In this connection a comparison of the figures relating to companies formed since the creation of the Commission with those formed prior thereto, is interesting. In all 90 companies have been incorporated with the approval of this Commission up to January 1st, 1909. Of these 49, or 55 per cent., are now in actual operation, and 13, or 14 per cent., have commenced the construction of their works, making a total of 62, or 69 per cent. of the 90 companies, which may be regarded as active. It must be borne in mind, however, that of these 90 companies only 36 were formed prior to January 1st, 1907, and of this number 27, or 75 per cent., are either now operating or have commenced the construction of works, leaving 9, or 25 per cent., which have failed to comply with the law, whose charters should be revoked. Of the remaining 54 companies incorporated between January 1st, 1907, and January 1st, 1909, sufficient time has not yet elapsed to determine the status.

Table No. 3 exhibits, as far as can be shown, the present status of companies incorporated between may 4th, 1905, the date of the passage of the act creating the Commission, and January 1st, 1909.



Delta of culm from coal washery—North Branch Susquehanna river above Wilkes-Barre.

TABLE NO. 3.

Present Status of Water Companies Incorporated May 4th, 1905, to January 1st, 1909.

Year.	Number incorporated.	In Operation.		Under Construction.		No Work Done Toward Construction of Plant.	
		Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
1905 (May to Dec., inclusive),	6	4	66	0	0	2	33
1906,	30	17	57	6	20	7	23
1907,	33	20	61	3	9	10	30
1908,	20	8	40	4	20	9	45
Total,	89	49	55	13	14	28	31

It will thus be seen, as indicating the effectiveness of the legislation creating this Commission in preventing speculation in water franchises, that as against an average of 58.4 per cent. of the total number of companies incorporated in 43 counties before June, 1905, which are active, 75 per cent. of the companies formed between June, 1905, and January 1st, 1907, are active. As against the formation of an average of about 120 companies per year for the five years immediately preceding the passage of the Act of May 4th, 1905, an average of but 26 companies per year have been formed for the three and one-half years since the Commission came into existence, a difference of 94 companies per year. One hundred and seventy-five companies were formed in the year and a half previous to the creation of the Commission, and by using the above ratio of 58.4 per cent. in determining their status, we find that 73 would not have used the privilges granted to them; while of the companies formed in the year and a half subsequent to the creation of the Commission, only nine are not active.

This difference would seem to indicate that the greater care exercised in granting charters, since the creation of the Commission, has resulted in the prevention of the formation of speculative corporations.

This Commission believes that the rights granted all water and water power companies being of great value to the State, should not be allowed to remain in the hands of the grantees unused, and that such grantees should not only be permitted, but should be compelled to surrender them. What appears to operate against the voluntary surrender of such franchises in a great many cases is the provision of the said Act of June 1st, 1889, preventing the voluntary dissolution of any corporation until all of its back taxes have been paid. While this Commission believes that it is of the utmost importance to require corporations to live up to their obligations in the matter of paying state taxes, it, nevertheless, believes that it is of still greater importance that the State re-claim valuable franchises heretofore granted rather than compel the grantees against their wills to retain them. In most cases the capitalization of such water companies, as have never operated under their charter, is small, and the amount of tax which the State could collect from them is insignificant in comparison with the value of the rights which they hold and which should revert to the State.

In furtherance of the reclamation of such franchises, therefore, this Commission would recommend:

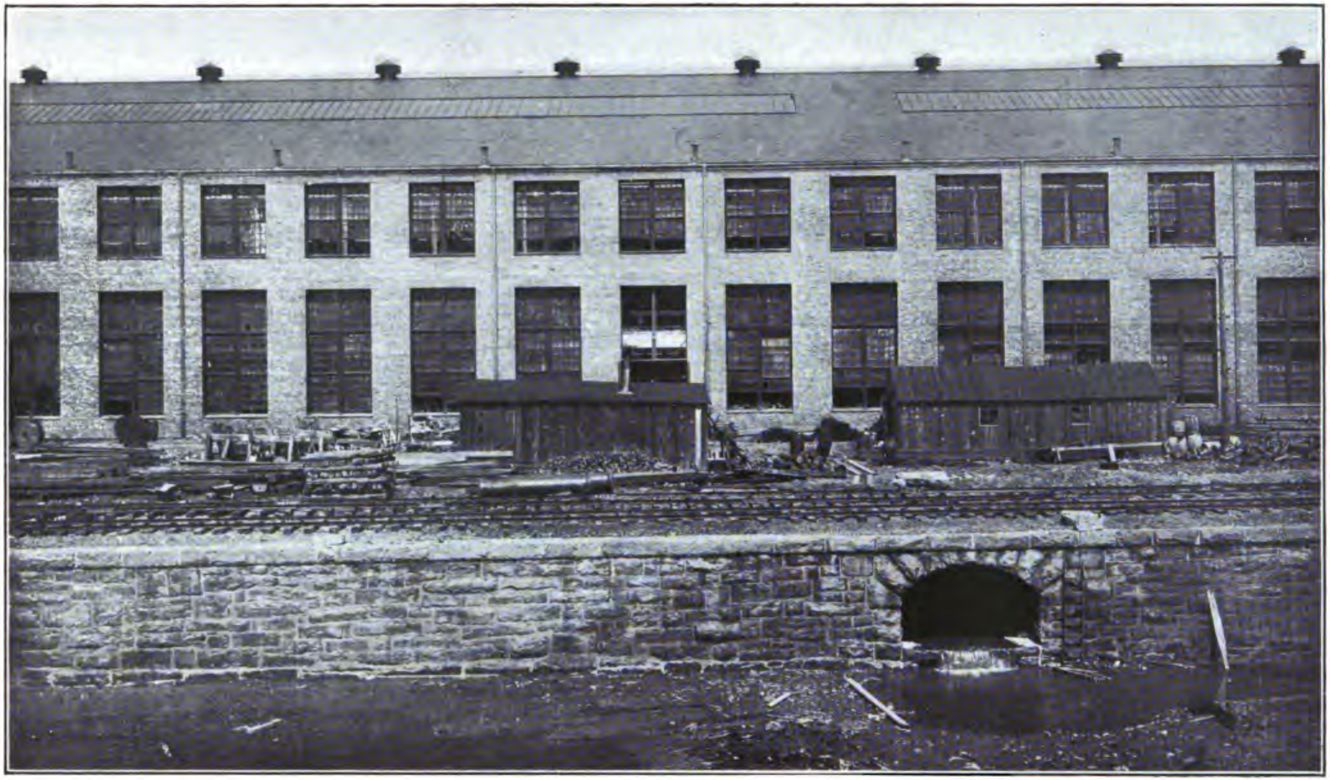
First: That the provisions of law contained in the Act of June 1st, 1889, requiring all taxes due the Commonwealth to be paid before a decree of dissolution can be entered, be amended, or changed, with regard to water and water power companies, so as to allow companies which have never made use of their franchises, and which do not intend to do so, to become dissolved and allow their franchises to revert to the State without the payment of such taxes.

Second: That water or water power companies which have not commenced the construction of their works, or commenced business within two years from the date of their letters patent, or have not completed such works within five years thereafter, be allowed, upon filing a statement of such facts, under oath, with this Commission, to become dissolved with the same effect as though a decree of ouster had been entered by court; and also that the Auditor General be authorized and required to certify to this Commission all affidavits or petitions of this nature which have heretofore been filed with him, and that such corporations be similarly regarded as dissolved.

Third: The enactment of a law authorizing this Commission, upon the determination of the fact of failure of any water or water power company subsequently incorporated to commence or complete the construction of their works within the time required by the existing law, to revoke such charter.

Fourth: The repeal or modification of the 5th Section of the Act of June 13th, 1883, so that no proceedings by the Attorney General would be necessary to terminate the corporate existence of any water or water power company which has failed to commence business within two years from the date of its incorporation.

Fifth: The amendment of the existing law providing for the extension by the Courts of Common Pleas of the period of time within which the plant and works of water companies must be completed so as to require the approval of this Commission to all such extensions.



Ashlar masonry retaining wall along Turtle Creek, Allegheny county.

CHAPTER 2.

OBSTRUCTIONS TO STREAMS AND METHODS OF BANK PROTECTION.

Previous to the passage of the Act of May 28th, 1907, involving the construction of encroachments in or along the streams of the Commonwealth, the waterways were unprotected by State supervision, their banks being encroached upon and their channels obstructed without regulation. If damage to other interests resulted from these works, recourse was had to the courts, and where injury was proved, compensation was made; but the courts necessarily considered such cases merely from the standpoint of the plaintiff and defendant and not with respect to the effect of such works upon the regimen of the stream. The latter influence is studied by the Commission and its decisions may, therefore, sometimes approve the construction of works, possibly injurious to individual or corporate interests, although beneficial, or at least not detrimental to the stream; but recognizing the right of injured parties to appeals to the courts for compensation for any damage inflicted, the Commission gives its approval with the proviso that full lawful authority exists for the construction of the proposed works.

Most of the applications received have been for the construction of bridges and dams, for the extension of river banks, usually for railroad purposes, or for the dumping of waste from industrial works. In cases where improvements or no apparent detriment to the stream will result, applications have been approved as made, while in other cases restrictive conditions have been imposed. In approving the construction of a bridge to replace an existing structure, the removal of the piers of the adjacent old bridge was required, in order that the channel should not be obstructed. A concrete arch bridge was approved on condition that the material excavated from the extensive pier foundations be deposited outside the high water channel. Applications for bank extensions have been approved on condition that the face of the slope be protected from erosion, by riprap or other suitable form of bank revetment.

The majority of the applications to the Commission, made in accordance with the Act of May 28th, 1907, come as a result of notification by the Commission that such works are unlawful and are to be discontinued, pending the approval of an application. Violations of the act generally come to the attention of the Commission through protests or the reports of its employes, and but rarely are applications made without such notification. The difficulty experienced under the present system of successfully controlling encroachments and obstructions in streams, leads the Commission to feel that a systematic canvas of the State is essential to effect proper stream protection, but owing to its many other duties and the limited funds at its disposal, it has been impossible to enforce the Act in as systematic a manner as desired. Many obstructions are placed in ignorance of the existence of such a law, while it seems that many other transgressors of this Act do not realize that it applies to temporary as well as to permanent structures, and instances are numerous, of parties making injurious fills of culm, ashes, cinder and other debris, believing applications unnecessary, as much of the material would be washed out and away during freshets. There is apparently no thought of the ultimate deposit of this material further down the stream. Thus it is that the stream banks along many of the municipalities of the Commonwealth have been used for general dumping purposes, disfiguring the waterfront, narrowing the channel, and adding to the suspended matter carried during freshets.

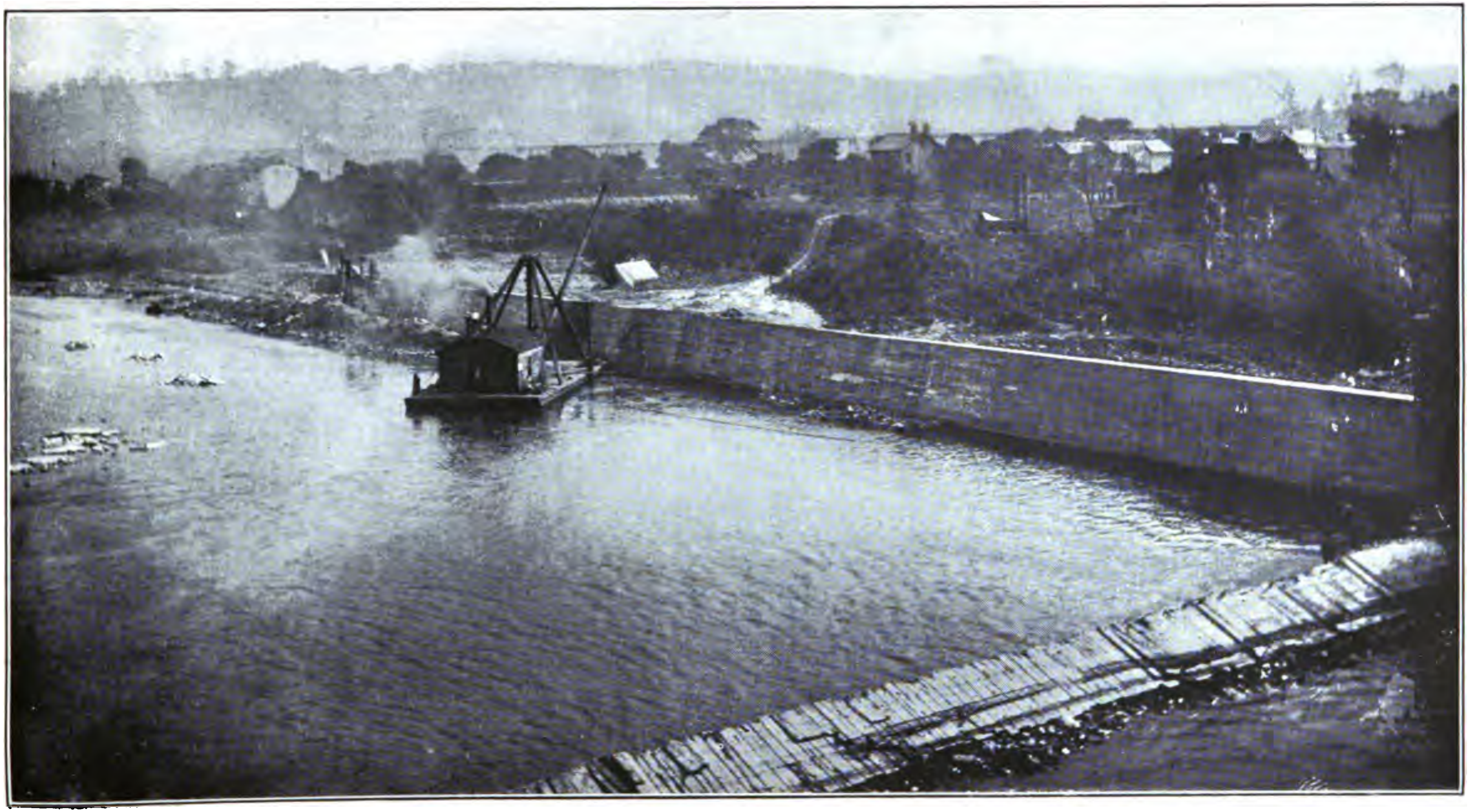
The prevention of this form of encroachment is both reasonable and desirable, and it is therefore recommended, in order that there may be no further misunderstanding, that the Act of May 28th, 1907, be amended so as to definitely name such deposits of ashes, slag, culm, and all other wastes and debris, whether placed permanently or temporarily.

The act gives the Commission jurisdiction only over streams which have been declared public highways by the Legislature, but on account of the silting up of the larger streams, caused by material washed down from the smaller tributaries, the Act should be amended so as to extend the jurisdiction of the Commission to cover all the streams in the Commonwealth.

CONCURRENT JURISDICTION OF STATE AND NATIONAL GOVERNMENT.

The United States War Department exercises supervision over certain portions of some of the larger streams of the state, and has improved navigation thereon for considerable distances. In most cases where such supervision is exercised, harbor lines have been established, beyond which encroachments are prohibited. The following table gives as nearly as can be obtained, the limits of active Federal supervision in Pennsylvania:

River.	Extent of U. S. Supervision.
Delaware,	Mouth to Morrisville, opposite Trenton, N. J.
Schuylkill,	Mouth, through City of Philadelphia.
Ohio,	State line to Pittsburg.
Monongahela,	Mouth to Pennsylvania-West Virginia Line.
Youghiogheny,	Mouth to West Newton.
Allegheny,	Mouth to Tarentum.



Gravity concrete wall for bank protection at West Bridgewater, Beaver county, Pa.
(The area behind wall, extending to the high bank, was filled in.)

In numerous instances a misunderstanding seems to have existed among those making encroachments as to the jurisdiction of the Water Supply Commission over the portions of the streams in the above list. In such cases the approval of the United States War Department and of this Commission is necessary before any changes in the current, course, or cross-section can be made, the approval of one organization alone being insufficient. The Federal authorities necessarily examine such applications largely in relation to their effect upon present and future navigation, while this Commission determines their effect upon the flood carrying capacity, addition of silt, deflection of the current, etc., as well. The Federal authorities and the Commission are working together in the endeavor to improve the condition of the stream channels and the former organization, dealing as it does usually with the lower reaches of the rivers, looks to the Commission for assistance through their supervision of conditions further up.

BRIDGES.

The larger streams have in few cases, been reduced in section by bridges to such an extent as to seriously impede flood flow, although some structures have not been built out of reach of the highest floods, for many have been carried out or damaged during freshets, as evidenced by the expenditures of the Commonwealth in their repair and rebuilding.* New bridges are as a rule placed higher above normal stream level than the older ones, and the plans for such structures, when presented to the Commission, are examined with this in mind. Some railroad companies are replacing truss by masonry arch bridges, and in their design it is necessary to compute carefully the waterway of the arched openings requisite for the passage of floods. In the case of truss bridges which are built too low the principal danger lies, not in their causing backing up of the water behind them, (although the trusses catch floating logs, timbers, ice, trees, etc., and sometimes form temporary dams which raise the elevation of the water), but in the actual damage to the structure itself, and, in case of failure, to other bridges below caused by the floating wreckage. The old wooden bridges, many of which still cross our streams, are particularly menacing to structures below, as the entire superstructure may float down on the flood and destroy other bridges. On smaller streams where the flood conditions are not so well known or appreciated, bridges and culverts have been built offering serious obstruction to the passage of freshet stages, and it is expected that data which the Commission has collected and is adding to, regarding the volume of stream flow during floods, will as published, assist in the better design of such structures.

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*1907 Report, Water Supply Commission Pennsylvania, page 80.

RIVER BANKS.

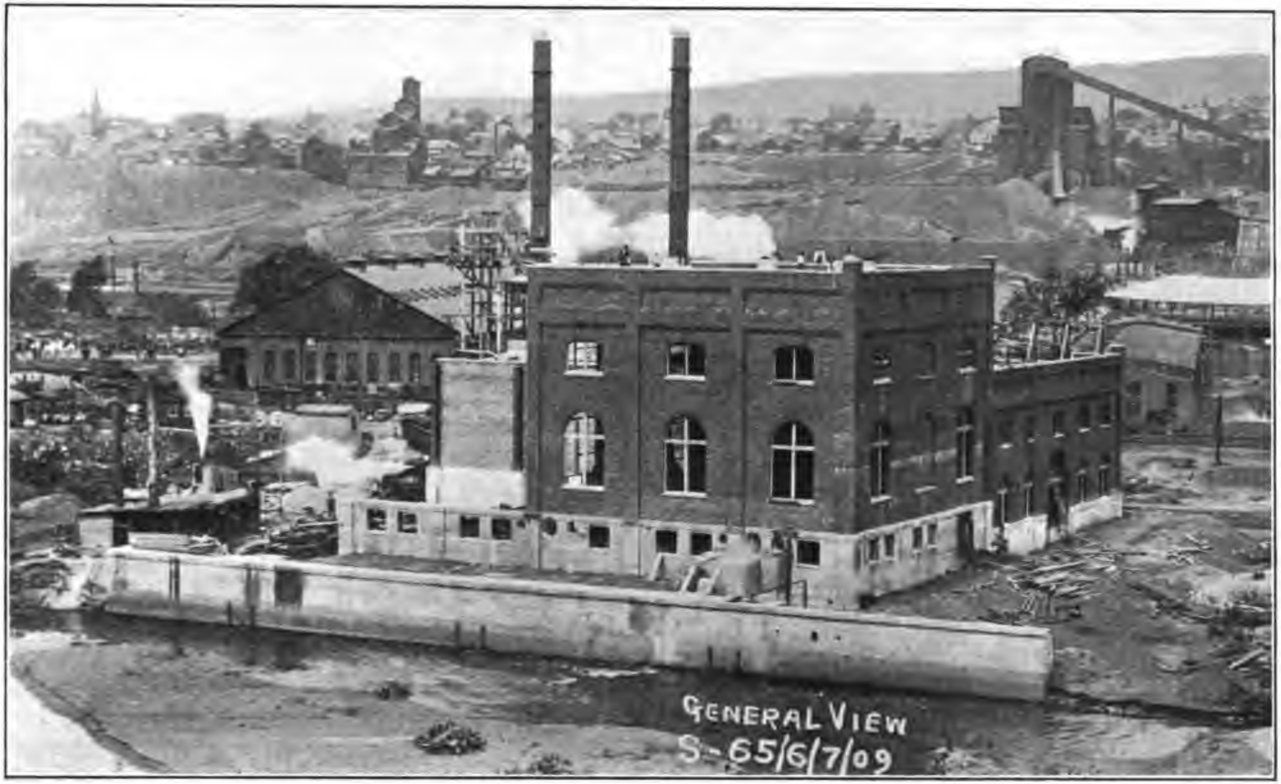
The class of obstruction upon which the Commission is most frequently called to pass, is the reduction of the cross-section by fills for various purposes. Applications from railroad companies involving the extension of the banks into the stream in order to provide additional track room or reduced curvature, and applications from manufacturing companies, for permission to dump waste products over the river bank, have come before the Commission during the year. Such fills when made of earth, ashes, fine cinder, etc., if not compacted and faced with some solid material, undermine and wash away, and in the case of fills for construction purposes, this material is replaced and the process repeated within a short period.

When proposed fills are to be located at points in the channel where the entire present cross-section is needed to carry the floods without overflow, or where a deflection of the current likely to cause damage below will probably result from the proposed obstruction, the disapproval of the work is considered advisable. Many encroachments involving the extension of river banks, however, are beneficial if the slopes are paved, for they may and often do involve the straightening of the channel, the filling out of fissures and the confining of the stream at wide parts where sedimentation is encouraged, thus tending toward a more efficient and permanent section. It has thus become evident both for permanency of work, and for protection against the deposit of sediment by the streams, that bank protective measures are essential.

The Commission is convinced that one of the menaces to the streams is the constant and increasing deposit in their beds of material washed from their banks and watersheds, from those of their tributaries or deposited therein from industrial works. The loose fills, which have heretofore been built along the rivers, and the great masses of refuse from mines, quarries and various industrial plants, dumped into the channels, when washed away, are deposited at points where the current slackens. In this way the levels of the stream beds are raised, and their slopes reduced, while at the same time their width is decreased by encroachments along their banks. Thus in three ways is the capacity for passing flood discharge reduced, the consequence being higher freshet stages and increased damage to bordering property.

CULM.

Perhaps the worst examples of silt filled channels are to be found in the anthracite coal region, where succeeding freshets wash the culm and fine coal from the waste banks which border the streams. Even in times of normal and low water this process is taking place, for many of the washeries direct their effluents, containing a large per-



Reinforced concrete retaining wall along Lackawanna river at Scranton.

centage of solid particles of culm, sand and coal, into the streams to be carried along by the current until the lessened velocity at some point causes its deposition. This usually takes place first and in largest quantity at the mouths of the small streams which receive their washings, when the rapid current usually prevalent in the smaller streams is checked by its meeting with the lesser velocity in the larger. The remainder is carried along by the larger stream to be deposited at its junction with one still larger or behind bridge piers, above dams or rapids, or wherever the current may be reduced. In time of flood these culm bearing streams overflow their banks and upon receding leave deposits of culm, sand and coal upon the meadows and pasture lands, often ruining them for agricultural use. This damage has been the frequent cause of legal actions, resulting often in the award of damages to the land owners.

The North Branch of the Susquehanna river below the mouth of the Lackawanna has been silted up in this manner, at some points as much at 12 feet in depth, while all the way down to Sunbury, and on the Susquehanna below Harrisburg, are deposits of this material, originally poured into the North Branch and into the main stream from the Lackawanna river, Nescopeck, Catawissa, Shamokin, Mahanoy, Mahantango, Wiconisco, and other smaller streams. Into the Schuylkill and Lehigh rivers pour likewise vast quantities of this material, to be deposited behind the navigation dams, and above rapids, gradually filling up the river beds and raising the flood crests. Conditions somewhat similar but not so aggravated exist in the bituminous mining districts.

While appreciating the serious conditions existing upon important streams in the Commonwealth due to the operation of coal mines, the Commission realizes the great importance of the coal industry to the state, and the necessity of considering the problem so as to give the greatest protection to streams without imposing unnecessary burdens upon the coal producers. As in the case of other obstructions, the owner of land damaged by the accumulation of coal waste or by changed stream channels, has legal recourse, but the stream discharge and the condition of the lower channels, can be considered and protected by the state alone, and the amelioration of these conditions is receiving careful consideration.

The investigations of the Commission have given it extended acquaintance with the condition of the banks of Pennsylvania streams, and increased familiarity with this problem has led to the belief that steps must be taken for their better protection against erosion along both large and small waterways. By insisting upon the proper protection of stream banks, in approving applications, much benefit is being obtained, and it is believed that a discussion of the methods of bank protection as practiced in Pennsylvania will lead to beneficial results.

METHODS OF BANK PROTECTION.

That the older nations of Europe have appreciated the necessity of protecting the banks of their rivers, is shown by the following quotation from a paper presented at the Convention of the Lakes-to-the-Gulf-Deep Waterway Convention, in October, 1908.*

"The greatest rivers in France, Germany and the adjacent countries, are small when compared with the Mississippi, yet they have done wonders in their development. They have compelled them to flow in fixed channels along the routes established by the engineers. Their floods are confined and controlled between fixed barriers so well constructed that they practically never break. Their banks are so well paved that they contribute little or nothing to the load of silt brought down by the smaller tributaries."

Isolated portions of river bank have been protected in Pennsylvania, the work having been done by State, municipal and corporate bodies, but few of these works are extensive, and they have not been built for the purpose of improving the rivers, but as protections against them. A large amount of this class of work has naturally been done by the railroads, whose lines generally follow the water courses, but in proportion to the amount of exposed river bank, very little has been done by these corporations.

The methods of bank protection as practiced in this state may be divided, according to material or design, into six (6) classes as follows:

1. Masonry walls.
2. Riprap paving.
3. Concrete facing.
4. Loose stone filling.
5. Slag walls.
6. Timber cribbing.

MASONRY WALLS.

Masonry walls are the most prevalent type of river bank protection in Pennsylvania, and such walls have been more frequently built of stone, either rubble or ashlar, than of concrete, but the latter material is now being used quite widely. Where streams pass through thickly inhabited districts, towns or cites, they are frequently walled along both banks, which are by this means effectively protected from washing. Rubble walls, being usually inexpensive, have been extensively used, and more costly walls of cut stone have been built where permanence and esthetic features are desired. Among the older works of this character are the walls at the dams and locks of the State and corporate canals, a fine example being

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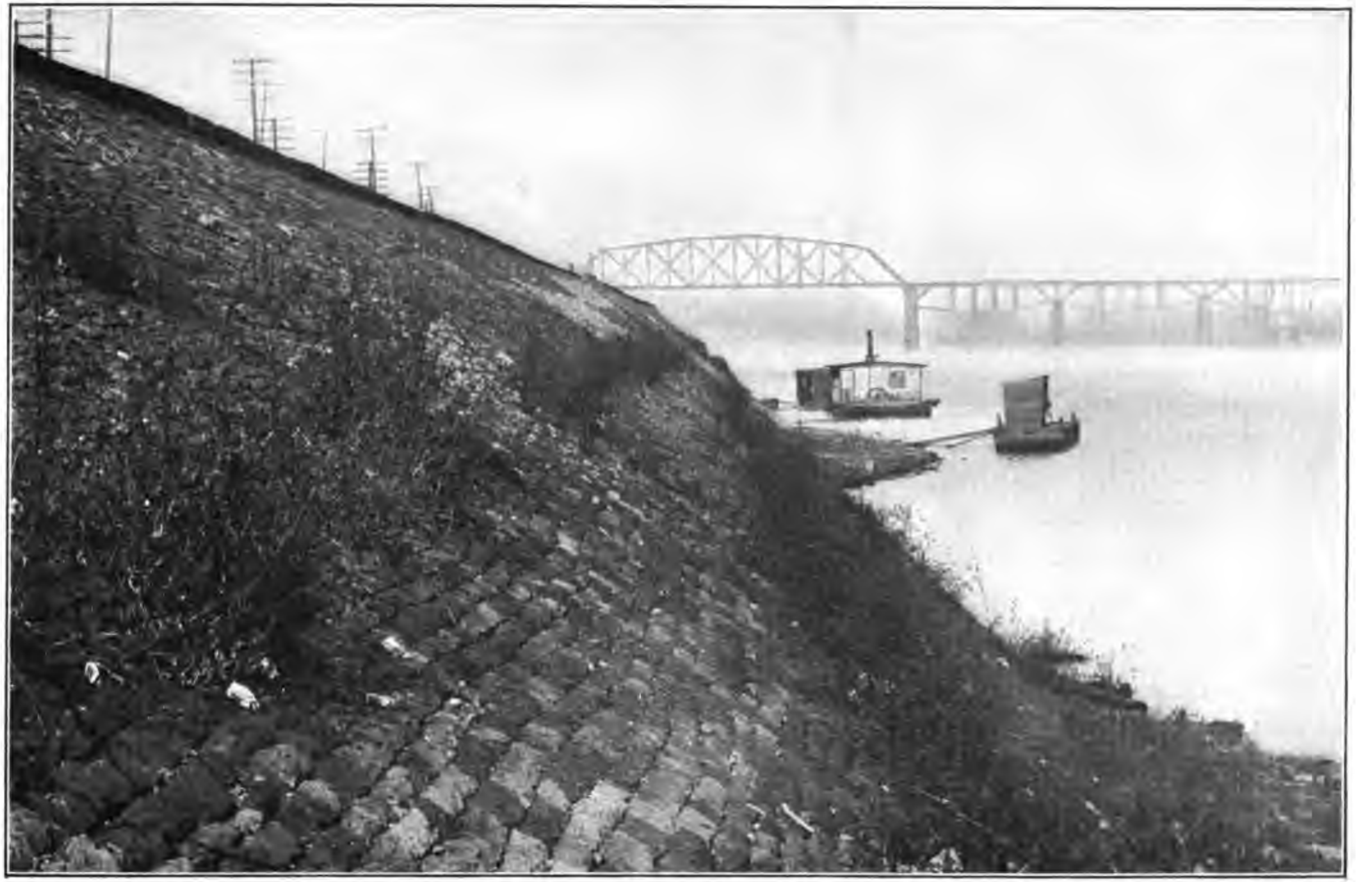
*J. A. Ockerson, American Representative, 11th International Congress of Navigation at St. Petersburg, June, 1908.



Riprap paving for bank protection by P. & L. E. R. R. Co., on Ohio river, west of Pittsburg.

that built along the Susquehanna river, at Clark's Ferry, 15 miles above Harrisburg. This wall is 2.5 miles long and 15 to 20 feet in height, was built over 70 years ago of dry masonry and is in good condition today. Its top is three feet in thickness and its base 6 to 8 feet. This type of wall protection was constructed by the Pennsylvania Canal Commissioners for the inlets from the river at the Nanticoke and Mifflintown dams, and at other exposed situations. "This construction served the requirements to protect the canal from damage of ice and other river floods, generally speaking, and when the wall suffered occasional damage the necessary repairs could be readily supplied."* Another example of a first-class ashlar wall is that bordering both banks of Turtle creek, Allegheny county, where that stream passes through the Borough of East Pittsburg.

In recent years concrete walls seem to have in large measure displaced the construction of ashlar walls, being usually less costly and as durable. At West Bridgewater, Beaver county, The Water Supply Commission built, under the Act of June 13th, 1907, P. L. 553, during the summer and fall of 1908, a concrete wall of the gravity type, where the bank of the Beaver river had, from the abutment of the lower dam, to the mouth, been cut back in places 150 feet, the main object of the work being to reclaim the land and to restore the water front for wharves and landings. The bank is about 30 feet above normal water and is composed of loam, clay and gravel, but as the river rises during extreme floods to a depth of several feet over most of the town, this work was not intended to prevent overflow at such times. The aim was to prevent the undermining of the bank at usual high stages, and to permit of the eventual reclaiming of the lost ground. The object being to regain the water front street, and still not to run out a long sloping bank, it seemed wise to build a retaining wall along the water's edge, filling in the land behind it. The wall is 640 feet long and 15 feet high, the foundation being partly on rock and partly on gravel. It is 7 feet wide at base and 2 feet wide on top, the north end joining the dam abutment. Sufficient fill to bring the whole area behind the wall up to the elevation of its top was placed, the funds appropriated not being sufficient to raise this area to the general level of the surrounding territory, but it can, under proper direction, be used for dumping purposes and soon be brought to the requisite height. The wall was built by contract, of boulder concrete, costing $5.00 per cubic yard, and the filling, also by contract, consisted of gravel dredged from the river and blast furnace slag, costing $0.40 per cubic yard. The wall itself cost $18.50 per linear foot.

Another example of this form of structure is the wall on the Monongahela river, protecting the property of the National Tube Co., at

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*T. T. Wierman, President of the Pennsylvania Canal Company.

McKeesport. This wall was built on the "cost plus a fixed sum" basis at an expense of $174,962, including general expenses, or at the rate of $10.50 per linear foot, the actual cost per cubic yard of concrete being $5.69.

The wall recently built by the Scranton Railways Co., along the North side of the Lackawanna river at Scranton, is an interesting example of a reinforced concrete wall, which besides protecting the bank, is used for carrying conduits, intakes, etc. It is 180 feet long and from 17 to 19 feet high, rests on a rock foundation, and is similar in section to a hollow dam, consisting of front and back faces, joined by counterforts every 12 feet. The space within the wall, approximately 4 feet in width, is occupied by conduits, flumes, intake wells, etc. The back wall consists of a slab 24 inches thick at base and 9 inches at top, reinforced with vertical and horizontal bars. The river face is 24 inches at base and 12 inches on top, without reinforcement, the counterforts being 18 inches thick and reinforced. The work cost $11.95 per cubic yard of concrete or $32.04 per linear foot complete.*

The Philadelphia Department of Wharves, Docks and Ferries has built extensive bank protective works along the two rivers in that city, the general practice consisting of three forms, riprap paving, timber cribbing or bulkheads, and concrete walls. The two latter methods being more expensive, are adopted where land values are high and where vessels use the shore for landings. The concrete walls built by this organization usually extend but a few feet above high tide, and rest on piles, the water face being usually vertical and the back face stepped off.

RIPRAP PAVING.

Where a wall is not necessary and a long slope is permissible, such slopes have been in certain instances paved with riprap to protect them from erosion. Riprap is usually placed on well compacted earth fill or upon loose stone fill, and when well laid has proved a satisfactory form of bank protection. This class of work has been quite widely adopted, and has been suggested by the Commission in certain instances, in connection with the approval of fills, conditioned upon the protection of the slopes.

Some of the railroads have realized that it is more economical to protect embankments where subject to river wash than to refill them after erosion by freshets. The Pittsburg and Lake Erie Railroad Co., whose tracks follow the south bank of the Ohio river from Pittsburg to the mouth of the Beaver river, has protected about three miles of the bank of that stream within the limits of the city of Pittsburg, the riprap being placed upon a fill of earth and cinder, costing about $2.00 per square yard of surface.†

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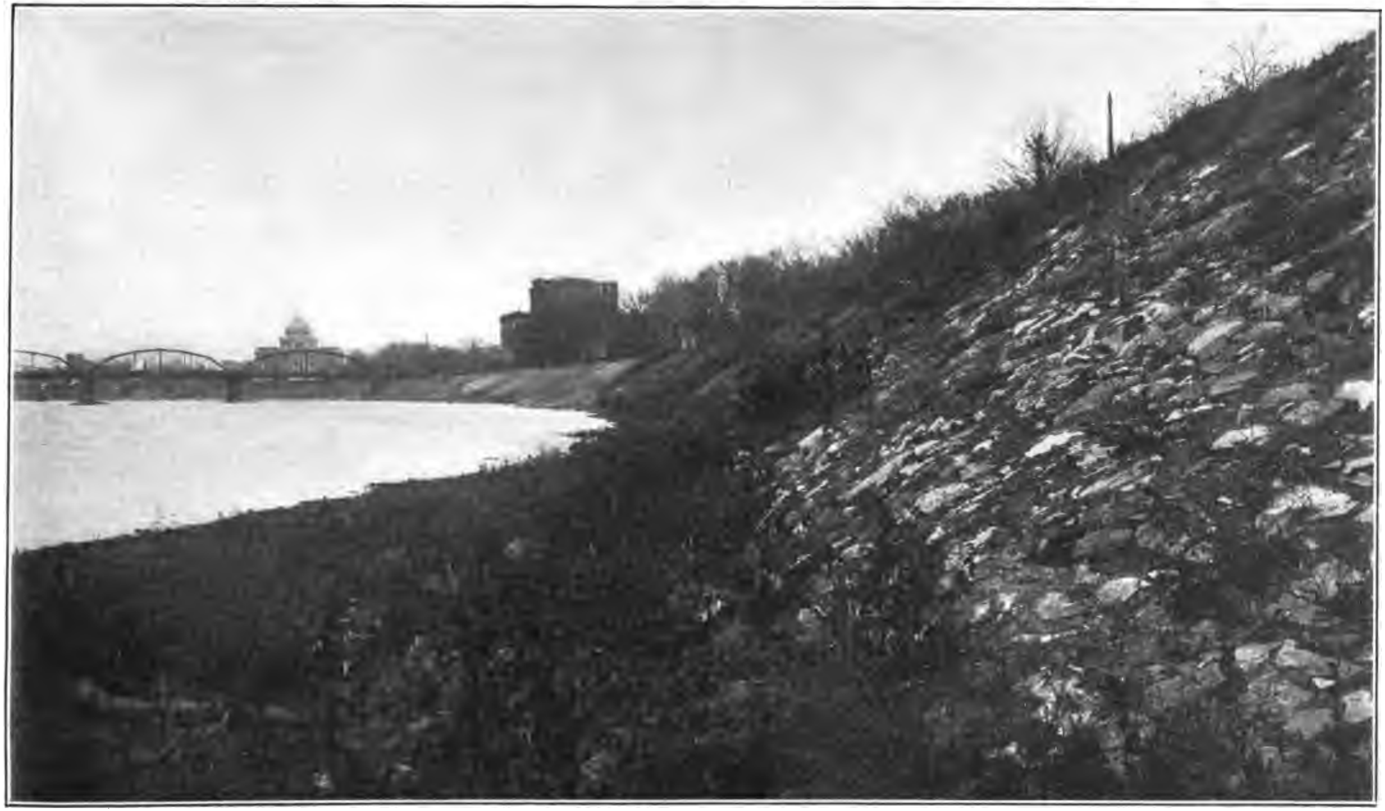
*Frank Caum, General Manager, Scranton Railways Co.
†J. A. Atwood, Chief Engineer, P. and Lake Erie R. R.



Earth fill, riprap faced, bank protection at Wilkes-Barre, Pa.

"Ripraping banks on this road is a very important matter, as this road runs close to the banks of the Mahoning, Ohio, Youghiogheny and Monongahela rivers at several points between Youngstown, on the Mahoning river, New Haven on the Youghiogheny, and Brownsville, on the Monongahela river, for a distance of about 165 miles along these rivers. At some points where riprapping is required and the tracks are far enough away from the harbor line to permit, the riprap is done by throwing stones over the bank, letting them roll or slide down, making a slope about 1 to 1½, slope varying in thickness from 2 to 4 feet. For this work quarry spalls are used or small stone such as can be handled by one man, and in some cases furnace slag, which becomes hard from the effects of the weather and makes very good riprapping, costing from one to two dollars per square yard. At points close to the harbor line stones such as can be handled by one man are used and laid in place by track laborers on a slope of one on one, varying in thickness from two to three feet, costing about three dollars per square yard.........In riprapping piers and abutments of bridges, in some cases where the current is not very rapid, small stone such as can be handled by one man are used, and where the current is very rapid, large breakwater stones, usually dropping them around the abutments or piers, allowing them to find their own bearing.

"In all cases the large breakwater stones filled in with small stones are preferable to fill up the crevices between the large stones and make the riprapping as compact as possible to prevent any washing."*

The river front at Wilkes-Barre has long offered a vexing problem, and about two years ago the improvement of the waterfront was taken up by a Park Commission. The bank which is underlain in some sections with running sand had cracked and slid down in a wedge 20 or 30 feet wide, and the face of the slope was undermining and sloughing off with each rise in the river. This condition was corrected by driving piles along the foot of the slope to prevent future sliding, and filling out the bank to make a smooth, regular curve, extending for about a mile along the city front. The face of this slope was riprapped and vines planted between the stones, while one portion was filled with rock, all the earth and rock for this filling being furnished to the city free of charge. A total of $13,800 was expended on this work in 1907 and 1908 effecting the paving of 12,350 square yards and the filling which was necessary.**

Under authority of the Act of June 13th, 1907, P. L. 646, the Water Supply Commission constructed bank protective works of this type at Matamoras, Pike county, during the past year, and owing to the different conditions, and to the objects desired, a different design was employed from that at West Bridgewater, described above. The borough of Matamoras extends for about a mile along the west bank of the Delaware river at the extreme eastern point of Pike county, and its 2,000 population is largely of a residential character, its principal street, Delaware Drive, following the river bank. This street, originally 50 feet wide, had been reduced by continual caving of the bank, to little over 25 feet at some points. The clay bank, the top of which is about 25 feet above normal water level, is underlain by a gravel bed; at its junction with the gravel the clay has been gradually undermined and the bank above has been cut back by continued caving and sloughing off, and if this condition had been allowed to continue the entire street would in time have been destroyed. The protection of this bank involved its extension at some points and its contraction at others, so that the top of the slope formed a series of tangents, joined by curves of small radii, giving the street a comparatively uniform width of 38 feet. From its finished top the bank was graded and thoroughly compacted on a one to one and one and one-half slope down to the junction with the gravel. At the south end the top of the bank was raised 2 to 4 feet, in order to elevate it above the high water of October, 1903, at which time overflow at this point submerged adjacent streets. On this slope, up to the usual high water line, 12 inches of riprap was placed, at the toe of which, and set down into the gravel flush with the surface, was placed a row of larger curbing stones, to hold the fill and riprap. Above the riprap the slope was graded and seeded. This work was done by contract, and cost for the grading and filling, 83 cents per cubic yard for borrowed dirt and 41 cents per yard for fill which was placed from excavation, while the rip-rap cost 95 cents per square yard. The whole 2,200 feet of bank was protected for $10,000, or at the rate of $4.60 per linear foot.

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*Extract from committee reports to the Annual Meeting of the Association of Railway Superintendents of Bridges and Buildings at Washington, D. C., October, 1908.

**E. E. Jones, Secretary, Wilkes-Barre Park Commission.

Long stretches of the State canal banks were protected, where the lines were adjacent to the rivers, by a substantial form of riprap paving, much of which is intact today although the canals themselves have long been abandoned. "The embankment was given a slope of one to one and paved with stone laid on edge square to the face of the embankment, the depth of this paving ranging from 9 inches to 1 foot thick, and large and small stones and spawls being used, laid by common laborers. This type of construction was found economical as to cost and very durable in service. The base, of course, should be well secured against undermining, and the top finished with coping or otherwise secured against ravelling out."*

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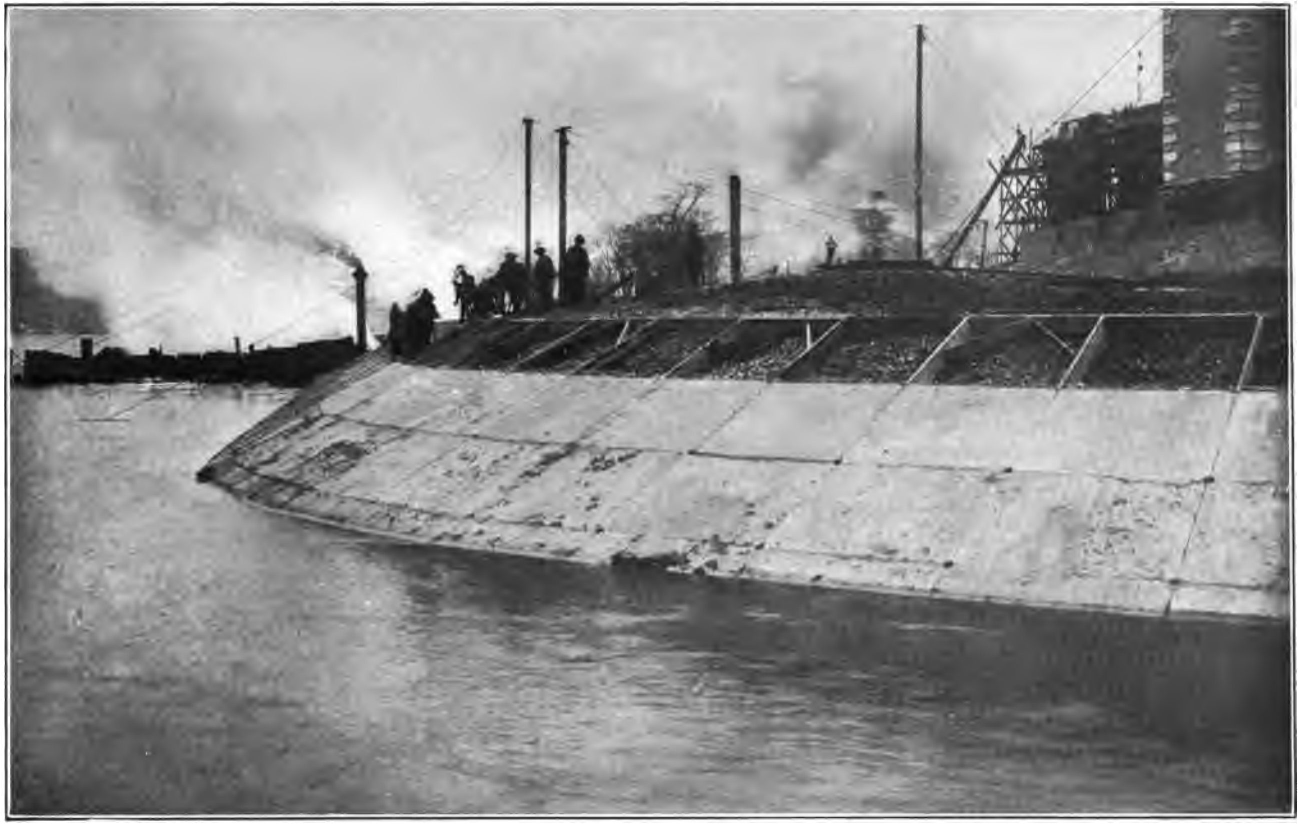
*T. T. Wierman, President of the Pennsylvania Canal Company.



Concrete paving for bank protection, Allegheny river at Pittsburg Filtration Plant.

CONCRETE PAVING ON SLOPES.

Recently the practice has been inaugurated of protecting the slopes with reinforced concrete paving in place of riprap, a form of construction probably more expensive than riprap but substantial in character and of good appearance. The facing on the dyke surrounding the Harrisburg filter plant, on Hargest island, in the Susquehanna river, opposite the city, is a first-class instance of this form of bank protection. The plant is on the upper end of the island, exposed to heavy ice flows, and as a break in the dyke would mean the shutting down of the filters, and perhaps the supplying of unfiltered water for an interval, it was deemed wise to protect this dyke in the most thorough way possible. An earth embankment 15 feet high surrounds the plant, the outside slope being 1½ to 1, on which was set 10 inches of spawl filling. On this bed was placed 4 inches of concrete, reinforced with small steel rods, the concrete extending to the bottom of a trench, along the foot of the slope. The earth filling cost 75c and 85c per cubic yard, depending on the length of haul, the spawl filling cost $1.00 per cubic yard, and the concrete cost $10.00 per cubic yard, or $1.10 per square yard.

The river slope of the clear water basin of the Pittsburg filtration plant at Aspinwall, on the west bank of the Allegheny river, is protected by a somewhat similar paving. This basin along the river about one half mile, its top being 31 feet above low water, while the sloping bank from its top down to the water line is subject to periodic rises of the river. The bank was first built on a 2 to 1 slope, following which 24 inches of coarse slag or gravel was spread and tamped. At the low water line piles were driven to support timbers forming a footing for 12 inches of concrete, which covered the entire slope from low water line to within two feet of the top of the bank. The total cost of this work, including slag base, concrete, piles, and footing timbers, was approximately $2.65 per square yard. It has been in place since January, 1907, and has shown no signs of weakness or need of repair.

On the north bank of the Allegheny river at Warren, Warren county, a small section of bank has been protected by an 8 inch covering of concrete, placed on a 1½ to 1 slope. It was stated that the concrete protection was cheaper at Warren, than riprap owing to the high cost of suitable paving stones.

LOOSE STONE FILLING.

Instead of building a sloping wall of earth and protecting it with some form of paving, such fills have been made in certain instances, when the rock is cheap, by dumping large boulders over the edge of the bank and allowing them to assume their natural slope. Such was the method used on a portion of the Wilkes-Barre waterfront, mentioned above. This form of construction has been used by railroads in disposing of material from rock cuts and tunnels. The large stones are not easily moved by the current, but might be disturbed by large areas of floating ice.

SLAG WALLS OR BANK PAVING.

The larger steel works of the State have found that a most satisfactory wall or slope protection can be built of the slag and cinder refuse from the furnaces. Such works, being quite generally located along the large streams, have found some method of bank protection necessary, not only for the preservation of the banks, but further the practice of using the waste products for this purpose offers a cheap means of its disposal, which has become, at some works, a problem of no small importance. Along the Ohio, Allegheny, Monongahela, and Youghiogheny rivers in the vicinity of Pittsburg, and at points on other streams where steel works line the banks, protection against bank erosion has been effectually obtained by this means, and in some instances this material has apparently resisted the action of the water for long periods. A common method of constructing such work is to excavate a foundation trench and lay up by hand a section of wall of cold slag blocks. Hot, moulten slag is then run down behind this wall, the semi-liquid material forcing itself into the interstices of the wall and welding the blocks together. When the ground behind has been filled to the level of the top of the first section of dry wall, another section is built on top of it, and the process is repeated to any required height.

The Jones and Laughlin Steel Company has about 2 miles of slag wall along its Pittsburg plant, 7,000 feet of it ranging from 17 to 28 feet in height, above low water, while some of the remainder is as high as 44 feet. "While some of this bank has been extremely satisfactory, other parts of it show a tendency to wash out underneath, allowing the slag to fall."* ....One section "about 2,000 feet long and 30 to 44 feet high, is 15 or 16 years old and shows no sign of wear and seems to be almost as good as concrete. In general, it would seem to form a most excellent wall if selected with a little care and properly placed. In such cases where it has been undercut the trouble seems to be with the nature of the soil underneath, rather than with the slag."*

The Cambria Steel Company has protected the banks of the Conemaugh river and Stony creek, at Johnstown, for many years with a fill of blast furnace slag and works refuse. "The furnace cinder is slightly soluble and at the water line slowly dissolves, permitting the upper part of the bank to slip down into the water. Where it has been possible we have been using cupola cinder, which is nothing but an impure glass and is not soluble."**

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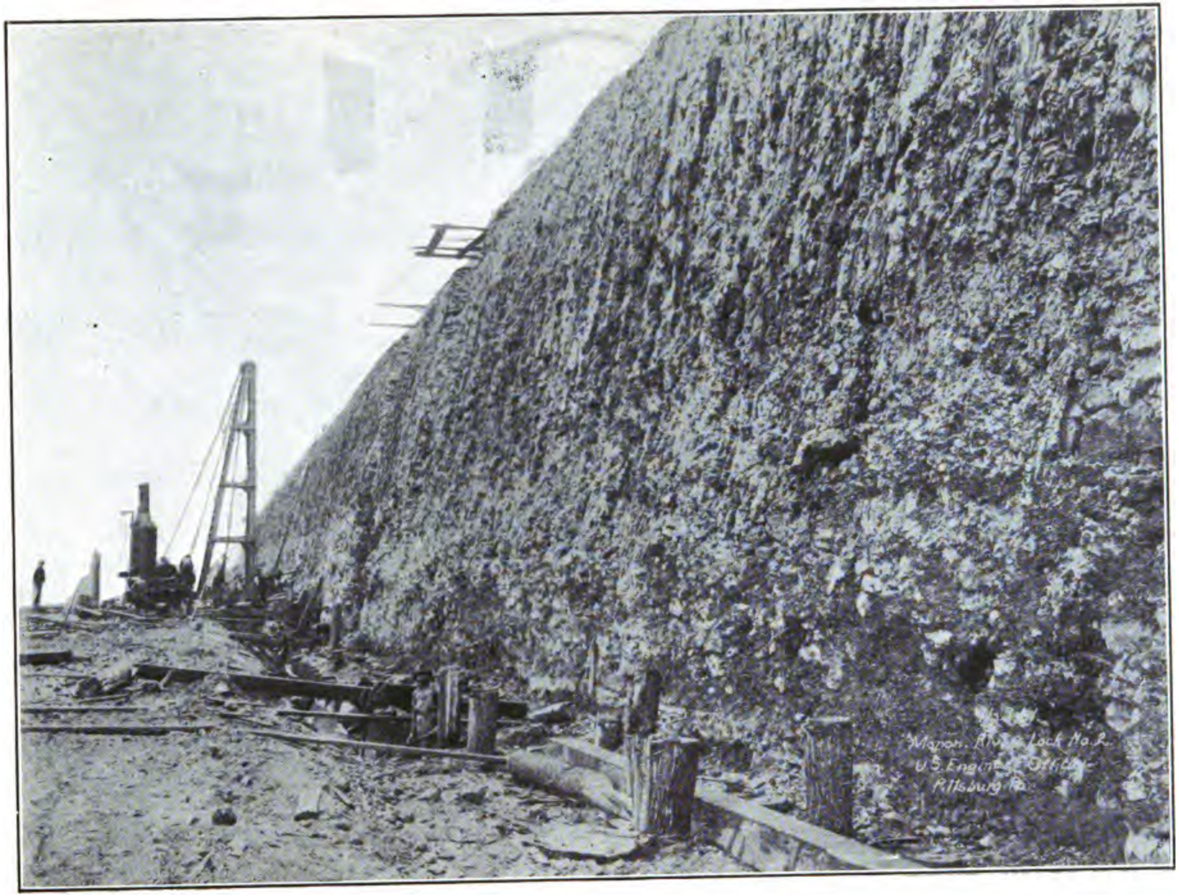
*Chief Engineer, Jones and Laughlin Steel Co.

**C. S. Price, Vice President and General Manager, Cambria Steel Co.



Wall built of steel works slag on Monongahela river.

Formerly these walls were often built without first finding proper foundations, the chief endeavor being to dispose of the slag, and many such banks have been undermined and are disintergrating, but when proper foundations are prepared and care employed in construction, most satisfactory results have been obtained.

TIMBER CRIBBING.

Perhaps the oldest method of bank protection practiced in Pennsylvania, and still widely in use, is the construction of timber cribbing against the bank, or the extension of such a construction into the stream, to effect a change in the current and thus protect a section of exposed bank. This form of construction is not so permanent as masonry walls or slope paving, but is often cheaper in first cost. The most extensive work of this character has been done along the Delaware and Schuylkill rivers, in Philadelphia, where many miles of river bank have received this treatment. The Philadelphia work consists usually of heavy timbers built up along the water front, supported on piles and tied to the bank by cross timbers bolted to piles, and filled in behind with stones and earth. In most instances such works have proved efficient and durable, failing with the rotting of the timbers, exposed as they are to the continued rising and falling of the tide. This cribwork is particularly applicable to use along navigable rivers.

A section of the bank of Hargest Island, Harrisburg, above mentioned, has been protected from wash by the erection of a rock filled crib jetty. The island rises from 10 to 15 feet above low water, and the loose earth and gravel bank, long exposed to the river, receded slowly to such a point that some form of bank protection was necessary. A stone filled, crib jetty was run out into the river a distance of about 150 feet, at an angle down stream, beginning at the elevation of the top of the bank and gradually reducing in height as it leaves the shore. It is placed at the upper end of the section of bank which it is designed to protect, the idea being that the slack water caused below it will cause the deposition of material, and gradually effect an extension of the bank below, while the jetty will also deflect the current from the shore and stop the cutting.

The Pennsylvania Railroad Co. is building timber cribs and jettys along portions of the river banks parallel by its lines, typical examples of which are to be found along the Conemaugh river above Conemaugh, where a rapid current and sinuous course causes considerable bank erosion. Along this streach of the river four sections of cribbing have been built, the total length being 772 feet. Extensive foundations are not generally used with such cribwork, the heavy timbers being built up against the bank, or as jettys, and filled with loose stones. The cost of these sections of cribbing was $2.45 per linear foot for material and $1.78 per linear foot for labor.*

Timber crib protection was used at the dams and along log chutes of the state canals. "The front and back walls were made of hewn timber 12 inches thick, 30 foot lengths and upward, hemlock and yellow pine, costing around $15.00 per M. ft. B. M., and oak ties......spaced 10 feet apart, and notched into the range timbers at each end.........The face of the completed crib wall next to the river was sheeted with oak plank.........These cribs were filled with stone, the top course laid on edge to serve as paving, for protection against the ice and river currents. The life of timber cribs of this type is 15 to 20 years, after which the timber has decayed, requiring renewal."**

In the above discussion it has not been attempted to include all examples of bank protection in the State, but to cover the various types of works which have been built, giving typical examples thereof. It is seen that the practice is quite varied, for no one form of construction would be applicable to all the various sets of conditions that may arise. Where fills are extensive inexpensive designs are essential, while in the case of a city water front, more costly design might be permissible. Where the municipal water supply is dependent upon the permanence of the work, as at the Harrisburg and Pittsburg filtration plants, the very best construction seems warranted.

So far as is known the States which surround Pennsylvania, and in which the tributaries of many of our streams rise, have taken no measures toward reducing the amount of silt carried thereby. The Commission contemplates taking up this question with the proper authorities in each such State, and endeavoring to obtain their cooperation in relieving the streams as much as possible, and in protecting the banks thereof.

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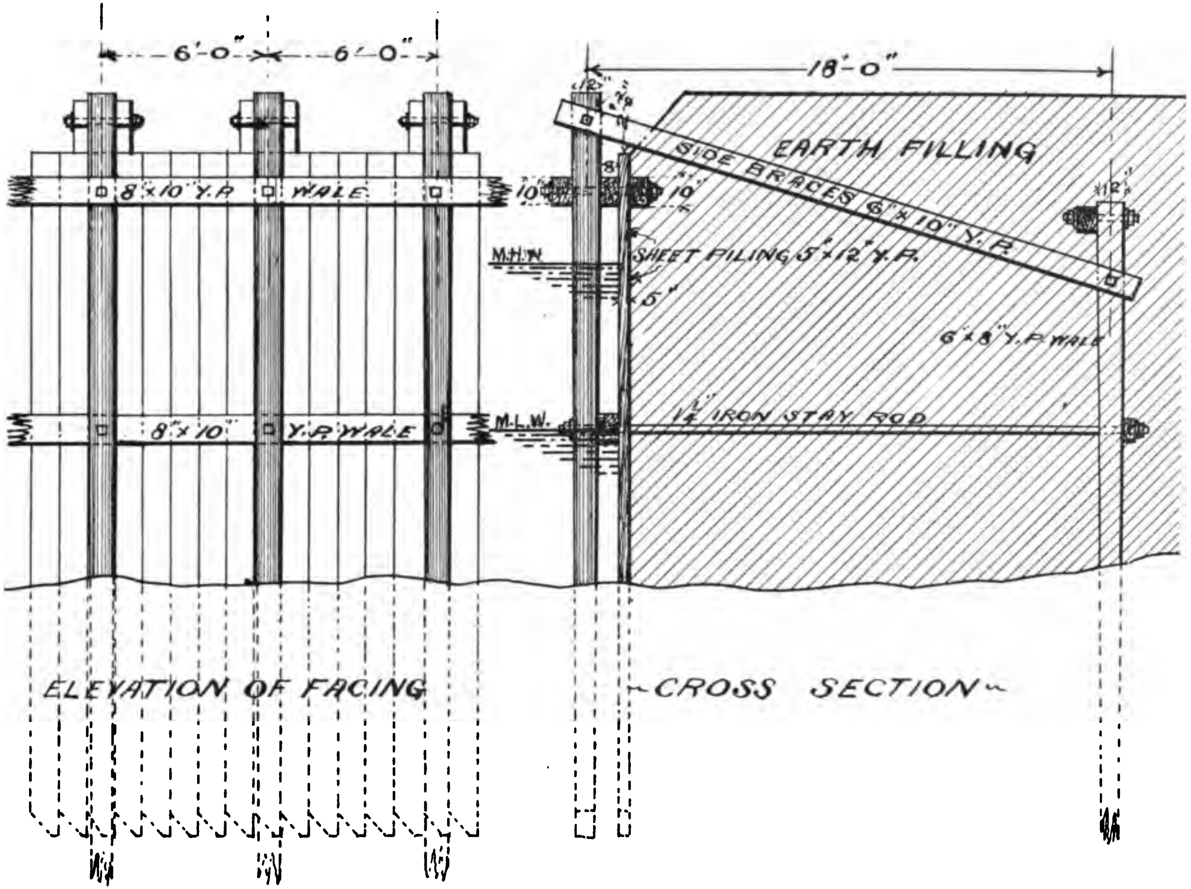
*S. C. Long, General Superintendent, Western Pa. Div. P. R. R.
**T. T. Wierman, Pres. Pa. Canal Co.



Timber crib work for bank protection,—Schuylkill river at Philadelphia.

CHAPTER III.

RAINFALL.

An investigation of the water resources of the Commonwealth involves a knowledge of the distribution and amount of the precipitation throughout its extent, for in the absence of applicable discharge measurements, rainfall records must be used for estimating stream flow. Rainfall may perhaps be best defined as the precipitation in the form of rain, snow or sleet, of the condensed moisture in the air, usually expressed in inches of depth over the surface. This condensation is caused by the resultant cooling of the atmosphere, when warm, moisture-laden vapors come in contact with cooler air currents. Warm air is capable of absorbing more moisture than is cool air, and consequently when warm air is saturated, a sudden drop in temperature results in the precipitation of the excess moisture which can no longer be held by the cooled air. This is well illustrated along the South Atlantic and North Pacific coasts of North America, where the warm, moisture-laden air over the sea drifts inland and gives a heavy rainfall when it is met by the cooler land breezes.

The winter, spring and fall rains and snows in Pennsylvania are mostly the result of storms covering considerable areas, traveling across the continent, usually from west to east, and by the time these storms reach Pennsylvania most of the original moisture, gathered from the Pacific ocean, has been precipitated, a fresh supply being gathered from the Gulf of Mexico, and finally from the Atlantic ocean. Much of the summer precipitation, however, is of a different character, thunder storms predominating, and such storms are purely local in causes and effects.

DISTRIBUTION OF RAINFALL OVER THE UNITED STATES.

A narrow belt of heavy average rainfall on the Pacific coast extends from Cape Flattery on the north to midway of the Oregon coast on the south, and inland as far as the summit of the Coast Range. In this, the region of greatest precipitation in the United States, the annual amount varies between 70 and 135 inches. In the east the area of greatest rainfall extends along the Atlantic coast from Mobile, Ala., around the Florida peninsula, and thence northward to Sandy Hook, New York, the maximum, 70 inches, occurring at Cape Hatteras, Virginia.; The following tables, Nos. 4 and 5, give the mean annual rainfall at points in these western and eastern regions of high precipitation.

TABLE NO. 4.

Rainfall along North Pacific Coast.

Station.	Term of record, years.	Precipitation in inches.
Tatoosh Island, Wash. (Cape Flattery),	14	93.3
Aberdeen, Wash.,	12	88.7
Glenora, Oregon,	12	136.3
Portland, Oregon,	32	45.6
Astoria, Oregon,	20	78.2
Eurica, Cal.,	17	45.8
La Porte, Cal.,	12	77.9

TABLE NO. 5.

Rainfall along South Atlantic Coast.

Station.	Term of record, years.	Precipitation in inches.
Mobile, Ala.,	33	62.1
Miami, Florida,	13	58.3
Savannah, Georgia,	14	52.7
Charleston, S. C.,	14	59.9
Wilmington, N. C.,	14	57.8
Kitty Hawk, N. C.,	13	60.0
Cape Hatteras, Va.,	14	70.0
Cape May, N. J.,	12-14	47.0
Sandy Hook, N. Y.,	12-14	51.0

Low rainfall occurs in the interior region, away from the oceans, the minimum precipitation being found where mountain systems obstruct the passage of moisture-laden air from all directions. Such conditions are especially noticeable in the desert portions of Arizona, Texas, California, Utah, New Mexico, Nevada and Colorado. Eastern Colorado is subject to an annual precipitation of about 12 inches; San Diego, Cal., during 54 years, 9.4 inches; while the lowest precipitation recorded in the United States is that Yuma, Arizona, the average for 28 years being 2.7 inches per year. The mean annual precipitation for the whole United States, as computed for the use of the United States Conservation Commission in 1908, is 29.4 inches.

The following table, giving the average annual precipitation for each State or larger geographic division, shows that Pennsylvania has a precipitation 18.3 inches above the average for the United States, ranking it as one of the well watered States. The rainfall is greater in the New England and most of the South Atlantic and

Gulf States and in the western portion of the North Pacific states, but it exceeds in slight degree that of the Lower Mississippi Valley States, and is materially higher than in most of the Central States.

TABLE NO. 6.

Average Annual Precipitation in United States or Larger Geographic Divisions†

State or Larger Geographical Division.	Average Annual precipitation in inches.
United States,	29.4
New England,	*40 to 50
New York,	*27 to 48.5
New Jersey,	47.7
Pennsylvania,	41.7
Maryland,	44.0
Virginia,	46.6
North Carolina,	52.0
South Carolina,	49.0
Georgia,	51.8
Florida,	54.5
Alabama,	52.0
Mississippi,	51.0
Louisiana,	57.6
Texas,	*10 to 50
Oklahoma and Indian Territory,	31.7
Arkansas,	46.7
North Dakota,	17.5
South Dakota,	20.3
Minnesota,	26.0
Wisconsin,	31.5
Michigan,	32.9
Nebraska,	23.6
Kansas,	*15 to 44
Iowa,	31.4
Missouri,	39.1
Illinois,	36.5
Indiana,	38.4
Ohio,	38.4
West Virginia,	42.5
Kentucky,	*40 to 53
Tennessee,	50.0
Montana,	14.2
Idaho,	15.3
Utah,	11.0
Wyoming,	13.0
Colorado,	*6 to 25
New Mexico,	13.0
Arizona,	*2.7 to 6
Nevada,	*3.4 to 12.4
Oregon,	*8.2 to 136.3
Washington,	*8.9 to 94
California,	*2.5 to 78

†Data largely taken from "Climatology of the U. S.," by A. J. Henry, 1906.
*Precipitation varies in different parts of the State between these limits.

DISTRIBUTION OF RAINFALL IN PENNSYLVANIA.

Rain falling in Pennsylvania is gathered from the Atlantic ocean and from the Gulf of Mexico, while in the extreme northwest, a small portion of the precipitation may result from proximity to the Great Lakes. The variation in precipitation over the State is less than that over many other States, the difference between reliable maximum and minimum annual records being approximately 20 inches. Over New England the precipitation is more uniform, showing a range of only about 10 inches; in New York it is slightly greater than in Pennsylvania, while in New Jersey and Maryland the variation is quite similar to that over this State. Owing to the size and shape of the State, however, the amount of rainfall shows considerable difference in its several sections. The State has no seaboard exposure, and its longest dimension extends in a westerly direction, nearly at right angles to the Atlantic shore line, the western boundary being about 400 miles from the ocean. The eastern end of the State, bordered by the Delaware river, is 60 miles back from the sea, and the rainfall in this section is doubtless influenced, to some extent, by its proximity. Over the eastern section of Pennsylvania, the precipitation comes largely from the Atlantic ocean, while much of the rain falling on the mountain and plateau region to the west of the Alleghenies presumably comes from the Gulf of Mexico. The general distribution of precipitation over the State is also influenced by local topographic features, which cause variations, probably greater in some instances than would result from the distances of these points from the sea, and among these local influences altitude seems to play a more important part than any other one factor, due to the interception by the hills and mountain ranges of moisture-laden air passing over them.

On the map on page 1, the lines of equal rainfall are determined by observations at nearly 200 stations, the averages of which records appear at the end of this chapter. Two classes of records have been plotted, those extending over a period less than 10 years, and those of a duration exceeding 10 years. In drawing the lines preference was given the longer records, the shorter ones being allowed to influence the curves only in the absence of more accurate data, and where observations are lacking these have been modified to a certain extent with reference to the topographic features, in so far as these would seem to affect the precipitation. Most of the United States Weather Bureau stations are in the river valleys, and it may fairly be assumed that they show a somewhat lower precipitation than on the hills.

The average annual precipitation for the State, 41.7 inches, was obtained by dividing the area of Pennsylvania into 57 approximately equal sections, determining a mean for each such section from the records within, or adjacent to, its boundaries, and then obtaining a mean of these 57 averages. The greatest mean annual rainfall is that recorded at Eagles Mere, Sullivan county, 67.1 inches, but the period of observation is short. Of the long term records, the greatest is 54.8 inches, at Girardville, Schuylkill county, while the least is at Pittsburg, Allegheny county, and at Towanda, Bradford county, both stations showing a mean annual precipitation of 35.9 inches. A short term record at Brownsville, Fayette county, shows an average precipitation of 32.4 inches per year. The approximate mean annual rainfall to which the various drainage basins are subject appears in Table No. 7, which indicates that, although at individual stations the short term records vary from 32.4 to 67.1 inches, and the long term records from 35.9 to 54.8 inches, there is not great divergence between the precipitation to which the various drainage basins, as a whole, are subject, the lowest being 38 inches, and the highest 46 inches.

TABLE NO 7.

Approximate Mean Annual Precipitation in Pennsylvania by Drainage Divisions.

Basin or Sub-Basin.	Approximate mean annual rainfall, in inches.
Delaware basin,	46
Susquehanna basin,	41
Ohio sub-basin,	38
Allegheny sub-basin,	42
Monongahela sub-basin,	41
Potomac basin,	42
Lake Erie basin,	38

An examination of the map shows that the lines of equal rainfall are irregular, while several small isolated areas of low and high precipitation occur, and that on the eastern border the precipitation is generally higher than in the central and western part, the highest being in the mountains of Schuylkill, and northern Berks counties, in the heart of the anthracite coal fields, due to its altitude and proximity to the sea, these being practically the first mountains to interrupt and cool the moisture-laden currents drawn in from the Atlantic ocean. The regions of the lowest precipitation are (1) across the central part of the northern borden, (2) in the southwest, (3) a small isolated area immediately east of the crest of the Alleghenies in Centre and Blair counties, (4) a long narrow strip in the south central part of the State, in Franklin, Adams, Cumberland, York, Dauphin and Lancaster counties, and (5) a narrow belt along the shore of Lake Erie, in the extreme northwest.

The assumption that much of the rain falling west of the crest of the mountains is drawn northward from the Gulf of Mexico explains the areas of high and low precipitation in that region; thus the region of high precipitation in Somerset, Fayette, Westmoreland, Indiana, Cambria, Clearfield, Jefferson and Clarion counties follows the high altitudes, intercepting the moist currents which have not been condensed further south. Surrounding this high area is a lower one, including most of the elevated plateau region of the north-west. In the low valley of the Allegheny, Kiskiminetas, Monongahela, Youghiogheny, Ohio and Beaver rivers, rain is less prevalent, owing to its interception by the higher altitudes to the south, while along the low coast of Lake Erie there exists a similar condition. The small area of low precipitation to the east of the crest of the Alleghenies in Blair and Centre counties may be explained by the fact that the many mountain ranges to the east intercept the moisture gathered along the sea coast, while the high crest of the Alleghenies to the west and south-west partly cuts off the rainfall from that direction. The greater part of the State is subject to from 40 to 45 inches annual precipitation. The area subject to this precipitation, as shown on the map, seems to occupy a fundamental or basic position, with the areas of greater or less rainfall carved out of it.

SEASONAL DISTRIBUTION OF PRECIPITATION IN PENNSYLVANIA.

The distribution of the rainfall throughout the year has an important bearing upon its value for agricultural and general water supply purposes. In certain portions of the United States there is a rainy and a dry season, most of the precipitation falling in the winter and spring months. Pennsylvania, however, does not have a marked wet or dry season, and for this reason derives greater benefit from its precipitation, for when seasonal distribution is unequal, ground, surface and artificial storage for tiding over the dry period has to be relied upon. More uniform seasonal distribution, however, aids the streams in maintaining their flow during the evaporating season and assists the crops during the growing season, obviating to some extent the necessity of storage.

In the latitude of Pennsylvania, during the winter months, the precipitation is largely in the form of snow and sleet, the ground surface being frozen much of the time, so that if the snow melts before the ground thaws, much of the moisture flows off in freshets. In the spring, however, the ground thaws, becoming moist and porous, and the water enters freely and passes into underground channels and reservoirs. During the summer months much of the rain is immediately absorbed by the dry ground, used by the growing plants and crops, or evaporated by the hot sun; while in the fall, less is used by growing plants and less is immediately evaporated, but considerable is absorbed by the dried earth. In general the winter precipitation is of less assistance in maintaining ground storage, as it usually passes directly off into the streams; that of the spring permeates the soil to a greater extent and fills the underground storage;

while the summer rains assist the growing crops and maintain, to some extent, the flow of the streams, and those of the fall replenish the depleted supply. In Pennsylvania the precipitation is fairly evenly distributed throughout the year, approximately equal amounts falling in winter, spring, summer and fall, as shown in the following table.

TABLE NO. 8.

Seasonal Distribution of Rainfall at Long Term Stations in Pennsylvania.*

Station.	Annual. Inches.	Precipitation.			
		Spring. Inches.	Summer. Inches.	Fall. Inches.	Winter. Inches.
Erie,	39.2	8.8	10.2	11.0	9.2
Saegerstown,	44.3	10.6	13.5	10.1	10.1
Emporium,	44.2	11.6	13.2	9.7	9.7
Leroy,	41.2	11.0	12.3	9.4	8.5
South Eaton,	38.2	10.0	10.7	9.0	8.5
State College,	40.2	10.8	12.0	8.8	8.6
Mauch Chunk,	50.5	13.1	13.8	11.5	12.1
Selins Grove,	44.1	11.6	12.8	10.5	9.2
Pittsburg,	36.8	9.4	11.4	7.5	8.5
Huntingdon,	42.2	12.0	11.6	9.3	9.3
Lebanon,	45.9	12.3	12.6	10.3	10.7
Quakertown,	45.2	11.3	12.3	10.8	10.8
Harrisburg,	38.1	9.9	11.5	2.3	8.4
York,	41.9	10.7	11.5	10.3	9.4
West Chester,	50.5	12.8	13.3	12.2	12.2
Philadelphia,	40.6	9.5	11.9	9.5	9.7
Average,	42.7	11.0	12.3	9.9	9.7

*From Bulletin Q—"Climatology of the U. S.," by A. J. Henry, page 213.

This table indicates that while the average precipitation in the four seasons is nearly equal, the rain falling during the summer exceeds slightly the precipitation during the other seasons, the next greatest rainfall being in the spring, while the winter precipitation is the least. Although not ideal for uniform water supply, these conditions are more favorable than distinct wet and dry seasons.

HISTORY OF RAINFALL RECORDS IN PENNSYLVANIA.

The earliest available rainfall records in Pennsylvania were taken in 1798, but the first general series for the State was started in 1887 and conducted under the direction of the Franklin Institute of Philadelphia, by authority of the Pennsylvania Legislature, and appropriations were made for defraying the expenses thereof, the United States Weather Bureau detailing officers to assist in the work from year to year. Under the provisions of the Act of 1889, the State Department of Internal Affairs commissioned the local observers and paid the bills as certified and presented by the Franklin Institute, and in the report of the Secretary of Internal Affairs for 1895 is published the climatological data for Pennsylvania to that date. The work was then taken up and has since been conducted by the United States Weather Bureau. The endeavor of the Federal authorities has been to locate and maintain an observation station in each county, but for many reasons this has not been possible, as the observers are voluntary, and but about 50 per cent. can be depended upon to keep accurate and continuous records, while the balance are constantly changing, so that many of the records are not continuous. The Philadelphia Bureau of Water has maintained a number of rain gages in the valleys of the Delaware and Schuylkill rivers, some of the records covering over twenty-five years. Other records have been kept by the United States Army Engineer Corps, municipal water departments, private water companies, educational institutions, hospitals and individuals. As far as possible, these records have been collected by this Commission for study and comparison, and those which seem trustworthy and of value are presented herewith. Out of a total of 277 different records obtained, 92 have been discarded as of doubtful authority or of too short duration. It was found that many records, though taken at important points, were so fragmentary as to render them comparatively valueless, while records at points of far less importance in determining the water supply have been maintained uninterruptedly for many years. Such conditions are bound to exist under the present system of employing voluntary observers, and a station of great value is liable at any time to be discontinued for similar reasons.

CHARACTER OF PENNSYLVANIA RECORDS.

As to the reliability of rainfall records, a quotation from a paper entitled "The Mean or Average Annual Rainfall, and the Fluctuations to which it is Subjcted,"* is presented. Based upon the assumption that care has been exercised in offering the records, "any good record of thirty-five years and upwards may be accepted within limits, and a record of fifty years is nearly as good as that of a longer perior," also "the conclusion may be drawn that dependence can be placed on any good record of thirty-five years duration, to give the mean rainfall correct within two per cent. of the truth; and that for shorter periods of five, ten or fifteen years, the probable extreme duration from the mean would be 15, 8.25 and 4.75 per cent. respectively." Few records in Pennsylvania extend over more than thirty years, and to judge from the author's deductions, we have in this State little first class data upon which to base estimates. There are, however, several records upon which great dependence may be placed, and others are rapidly becoming of a more reliable nature.

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*Alexander R. Bennie (Proceedings for 1896 of the Institute of Civil Engineers, London; Vol. 109, p. 89).

Heretofore, rainfall stations in this State have not been located with a view to using the results as a basis for the determination of stream flow, for the Franklin Institute and the United States Weather Bureau have employed a geographical basis for agricultural and general scientific purposes. Individual and local problems have been responsible for the measurement of rainfall at cer-

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“1. Rain, snow, hail, etc., are all included under the general designation, precipitation.

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Heretofore, rainfall stations in this State have not been located with a view to using the results as a basis for the determination of stream flow, for the Franklin Institute and the United States Weather Bureau have employed a geographical basis for agricultural and general scientific purposes. Individual and local problems have been responsible for the measurement of rainfall at certain points to determine run-off, such as the water supply problem of Philadelphia, and other cities. This method, however, has never been applied to the State as a whole; so that, although there are many records, the data obtained is not so valuable in determining the stream flow as it would have been had the stations been located with this object in view. Rainfall stations located in the collecting areas of streams are of more value in this work than those located in the valleys of the large rivers. One station properly placed adjacent to a number of watersheds may supply valuable data for each stream, and replace one station in each area. For the purposes for which they were placed, the locations of the Weather Bureau stations are in most cases satisfactory and practicable, but have resulted in making records sarce in sections where they would have been of the most value in determining stream flow.

METHODS OF MEASUREMENT.

The United States Weather Bureau maintains stations all over the United States for the observation of rainfall, and as many of the tables included in this report are taken from its records, it is deemed advisable to annex a short description of its methods. In the measurement of rainfall, the standard gage used by the United States Weather Bureau offers a simple and accurate method. The following text and sketches are taken from the "Pamphlet of instruction for the measurement and registration of the precipitation by means of the standard instruments of the United States Weather Bureau," under he title of "Measurement of Precipitation."*

"THE MEASUREMENT OF PRECIPITATION."

"1. Rain, snow, hail, etc., are all included under the general designation, precipitation.

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EXPOSURE OF GAGES.

"2. The exposure of gages is a very important matter. The wind is the most serious disturbing cause in collecting precipitation. In blowing against the gage, the eddies of wind formed at its top and about the mouth carry away rain, and especially snow, so that too little is caught. Snow is often blown out of a deep gage after once lodging therein.

"A. Rain gages in slightly different positions, if badly exposed, catch very different amounts of rainfall. Within a few yards of each other two gages may show a difference of 20 per cent. in the rainfall in a heavy rain storm. The stronger the wind the greater the difference is apt to be. In a high location eddies of wind produced by walls of buildings divert rain that would otherwise fall in the gage. A gage near the edge of the roof, on the windward side of a building, shows less rainfall than one in the center of the roof. The vertical ascending current along the side of the wall extends slightly above the level of the roof, and part of the rain is carried away from the gage. In the center of a large, flat roof, at least 60 feet square, the rainfall collected by a gage does not differ materially from what is collected by a gage at the level on the ground. A gage on a plain with a tight board fence 3 feet high around it at a distance of 3 feet, will collect 6 per cent. more rain than without the fence. These differences are due entirely to wind currents.

"B. Observers will, therefore, take particular care in selecting a place for the location of the gages, as the value of the records is sometimes greatly impaired by improper exposure. It is scarcely necessary to say that every precaution should be taken to protect gages from the interference of unauthorized persons and animals. Select, if possible, a position in some open lot unobstructed by large trees, buildings or fences. Low bushes and fences, or walls that break the force of the wind in the vicinity of the gages are, however, beneficial, if at a distance not less than the height of the object. Such a place, in general, affords the best exposure. Gages should be exposed upon roofs or buildings only when better exposures are not available, and when so located, the middle portion of a flat, unobstructed roof, generally gives the best results.

"3. In general, the rain and snow gages will be installed side by side, not nearer than three and one-half feet from each other, centre to centre of gage.

"Stations which use a recording gage will expose a standard 8-inch gage for use as snow gage, and during the warm season may use the same for checking reading of rainfall in cases of emergency.

"4. Snow fall is preferably measured as depth of water rather than by the thickness of layer it forms on the ground. When it can not be measured by melting, it is customary to take one-tenth the measured depth of the snowfall on a level open place as the water equivalent of the snowfall. The relation between the depth of snow and depth of melted snow is very different in different cases, depending on the wetness of the snow. The equivalent depth of water in some cases is as great as one-seventh of the depth of snow, and in others may be as small as one thirty-fourth. It is always best to [redacted]

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"Two forms of rain gages are in general use: 1. The Standard 8-inch cylindrical gage. 2. The Automatic, tipping bucket, self recording gage. The former is merely an 8-inch cylinder, exposed to the atmosphere so as to catch the rain as it falls. The depth of water in it is measured each day by the observer. The latter gage is automatic in that each .01 inch of rain collected is recorded on a register, and the observer simply reads this register each day. This gives a continuous record and also records each storm separately without the necessity of frequent observations."

TABLES OF PRECIPITATION.

The following records of Pennsylvania rainfall give, by drainage basins or sub-basins, the station; the average monthly; the mean, maximum and minimum yearly precipitations; the length of record; and the number of complete years included therein. The full daily and monthly records at each station have not been included on account of the space necessary, and by reason of the fact that the records will show data in sufficient detail for most uses. The Commission wishes to express its willingness to furnish the detail data concerning individual records upon request.

CHAPTER IV.

DROUGHTS.

The State of Pennsylvania, together with the larger part of the eastern and central sections of the country, has, during the past summer and fall, experienced an excessive and long continued drought, while since 1894 this region has experienced four periods of exceptional drought, each effectively illustrating the dependence of population, industry and commerce upon an adequate water supply, for as population, industry and transportation increase, the use of water becomes more extensive, and drought conditions are more acutely felt. The low condition of the sources of water supply, occurring during extended dry periods, impedes navigation and water power development, restricts the water supply for towns, cities and industries, and for steam transportation, etc., and injures agriculture, while the water is less fit for use, on account of the concentration of the impurities which are carried. Droughts, like floods, cause severe monetary losses and it is the certainty of their recurrence that retards or prevents the development of our streams to their maximum usefulness. The loss occasioned by droughts is usually of a less tangible character and more difficult to estimate than that resulting from floods, for drought conditions are not confined to the river valleys, as are the floods, so that in the aggregate the loss may be quite as great because more far-reaching.

Recognizing, therefore, that it is during times of drought that the true value of streams is to be determined, and anticipating that the drought of the summer and fall of 1908 might develop into one of exceptional intensity, the Water Supply Commission determined to make a more thorough study of rainfall, stream flow and water supply conditions throughout the remainder of the drought period than had been done in the past. The decision proved itself to be well founded as the data collected indicate that seldom, if ever, has this State in general been subjected to more serious drought conditions. The method of study adopted involved:

1. A broad system of stream gagings, and the collection of miscellaneous stream flow data from various local sources.
2. A census of the effect of low water conditions on municipal and industrial water supplies.
3. An analysis of the United States Weather Bureau precipitation records.
4. A comparison of the data collected with that previously recorded concerning past droughts.

It is difficult to state just what constitutes a drought, for the same deficiency in rainfall may cause drought conditions in one place and not in another, or in one year and not in another. A deficiency of 50 per cent. in a region subject to heavy rainfall may not cause so [illegible] the same deficiency in a more arid region, [illegible] of excessive precipi-

	Term of record.
Al	1886-92
Ba	1906-08
Br	1885-06
Ca	1894-07
Cl	1888-08
Co	1886-92
De	1896-08
Du	1891-97
Fra	1840-08
Fre	1888-08
Gro	1907-08
Hee	1898-08
Indi	1903-0[illegible]
John	1868-08
Ligo	1890-94
Lyci	1890-08
Maho	1884-95
Mead	1839-87
Oil	1877-05
Park	1885-08
Pitts	1840-08
Ridge	------
Saeger	1892-08
Saltsb	18[illegible]4-[illegible]8
Shingl	1896-01
Smeth	1839-05
Spring	1905-08
Stoyst	1891-95
St. M	1896-08
Tarent	1872-80
Warren	1840-08
G	
L	
A	

in 1876, and in 1881 a serious drought affected practically the whole country east of the Mississippi river, and lasted from July to September. At Pittsburg from May 7th to 29th, 1881, 23 days, but 0.6 of an inch of rain fell; from June 18th to July 15th, 28 days, only 1.0 inch fell, and from August 1st to September 25th, 56 days, the precipitation was but 1.25 inches. The most striking characteristic of this drought was its duration and the attendant high temperature, causing serious damage to vegetation and crops, and, in its later stages, a scarcity of water for domestic and manufacturing use. In many places scores of shops and factories were obliged to shut down for lack of water. In 1887 a drought affected the western portion of the State.

"The greatest drought this country has experienced in the last 100 years, both as to intensity and extent of territory covered, culminated in the Middle Mississippi and Missouri valleys in 1894, and in the Lake region and Atlantic coast districts in 1895. The drought of 1894 was the culmination of a period of deficient precipitation and high temperatures that began during the early summer of 1893. The subsoil, from which the surface soil by capillarity draws a portion of its moisture, had become appreciably dessicated and the way was open to a disastrous drought should the spring and summer rains fail. The rains of April were generally deficient in almost all parts of the country, except the northern Pacific coast, the Upper Mississippi valley and the Upper Missouri valley, although the deficiency east of the Mississippi was not especally marked, except along the south Atlantic coast. In May the greatest deficiency in precipitation, 3 inches or more, occurred in the States of South Dakota, Nebraska, Kansas, Iowa, Illinois and Missouri. In June, July and August the drought continued unabated in these States and extended into the upper Mississippi and Ohio valleys, the Lake region and portions of the Northeast and Middle Atlantic States. The months of July and August were exceptionally dry in the Ohio valley, the Lake region, the Missouri valley and the middle and upper portions of the Mississippi valley. Over this great region less than two inches of rain, on the average, fell in the two months. The shortage of rainfall during 1895 was almost as great and as widespread as in the previous year, but the region of greatest intensity was shifted from the middle Mississippi valley eastward to the Lake region and upper Ohio valley.

"Since the drought of these two years will probably become historic, a record of the departure of the anual precipitation from the normal is here given for future reference and comparison."*

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*From Bulletin Q, "Climatology of the United States," pages 51-52, 1904.

TABLE NO. 18.

Precipitation Departures in the Drought Years of 1894 and 1895.

District.	Departure, in inches.	
	1894.	1895.
New England,	—8.1	—5.3
Middle Atlantic States,	—5.3	—9.1
South Atlantic States,	—4.2	—3.7
Ohio Valley and Tennessee,	—11.0	—11.0
Upper Mississippi Valley,	—12.0	—7.8

In 1900 there occurred a period of low rainfall and low condition of the streams, caused by a dry spring and an exceptionally hot summer and fall, the minimum stream stages being reached the latter part of September and first half of October. The streams of the Susquehanna basin reached lower points than before known at many places, the Susquehanna at Harrisburg being approximately one inch lower than during the drought of 1895. These conditions continued, slightly relieved, until the latter part of November, when heavy rains broke the drought and raised the streams into sudden freshet condition. Water supplies for domestic and industrial purposes were affected during this period and considerable losses resulted. The following table shows the precipitation and temperature and their departure from the state normal by months, during the year 1900.

TABLE NO. 19

Showing Average Monthly Precipitation and Temperature in Pennsylvania for 1900 and the Variation from the Normal.

Month.	Average precipitation in inches.	Deficiency in inches, below normal.	Excess above normal in inches.	Temperature.	
				Deficiency.	Excess.
January,	2.64	0.70	-------	-------	2.0°
February,	4.22	-------	1.05	1.6°	-------
March,	3.61	-------	0.46	3.6°	-------
April,	1.57	1.57	-------	-------	1.3°
May,	2.79	1.96	-------	-------	0.7°
June,	3.60	-------	-------	-------	1.0°
July,	4.86	-------	-------	-------	2.5°
August,	3.33	0.64	-------	-------	5.1°
September,	1.77	1.52	-------	-------	4.7°
October,	2.74	0.80	-------	-------	7.7°
November,	4.10	-------	-------	-------	3.2°
December,	2.08	0.98	-------	0.7°	-------
Total of year,	37.31	8.17	1.51	5.9°	28.2°
Total for year,	-------	6.66	-------	-------	22.3°

The drought of 1904 did not extend so uniformly over the State as did those of 1895, 1900 and 1908, for in the Delaware Basin a dry spring was succeeded by a wet summer and fall, and the drought was less in evidence, so that the State averages of precipitation do not truly indicate the conditions. Table No. 20 showing the monthly precipitation in each drainage basin indicates that the deficiency in rainfall began over the Susquehanna and Ohio Basins in August, but that it did not reach serious proportions until November. This was, therefore, a late drought, its most acute stage coming with the advent of winter and being broken in most sections about December 10th, and beginning too late to materially injure the summer crops. The streams reached very low stages, some of them falling almost as low as, and a few even lower than, in 1900, and cities, towns and industries suffered through insufficiency of water supply, causing the temporary closing down of numerous industrial works. It has been stated that it was the loss caused during this drought that led one of the railroad corporations of this State to spend many millions of dollars in a new water supply system. The average precipitation during the year 1904 was 3.77 inches less than the normal for the State, and was the least since 1900. At the same time it was the coldest year since the organization of the Weather Bureau Service in 1888, the daily deficiency in temperature being 2.7 degrees.

TABLE NO. 20.

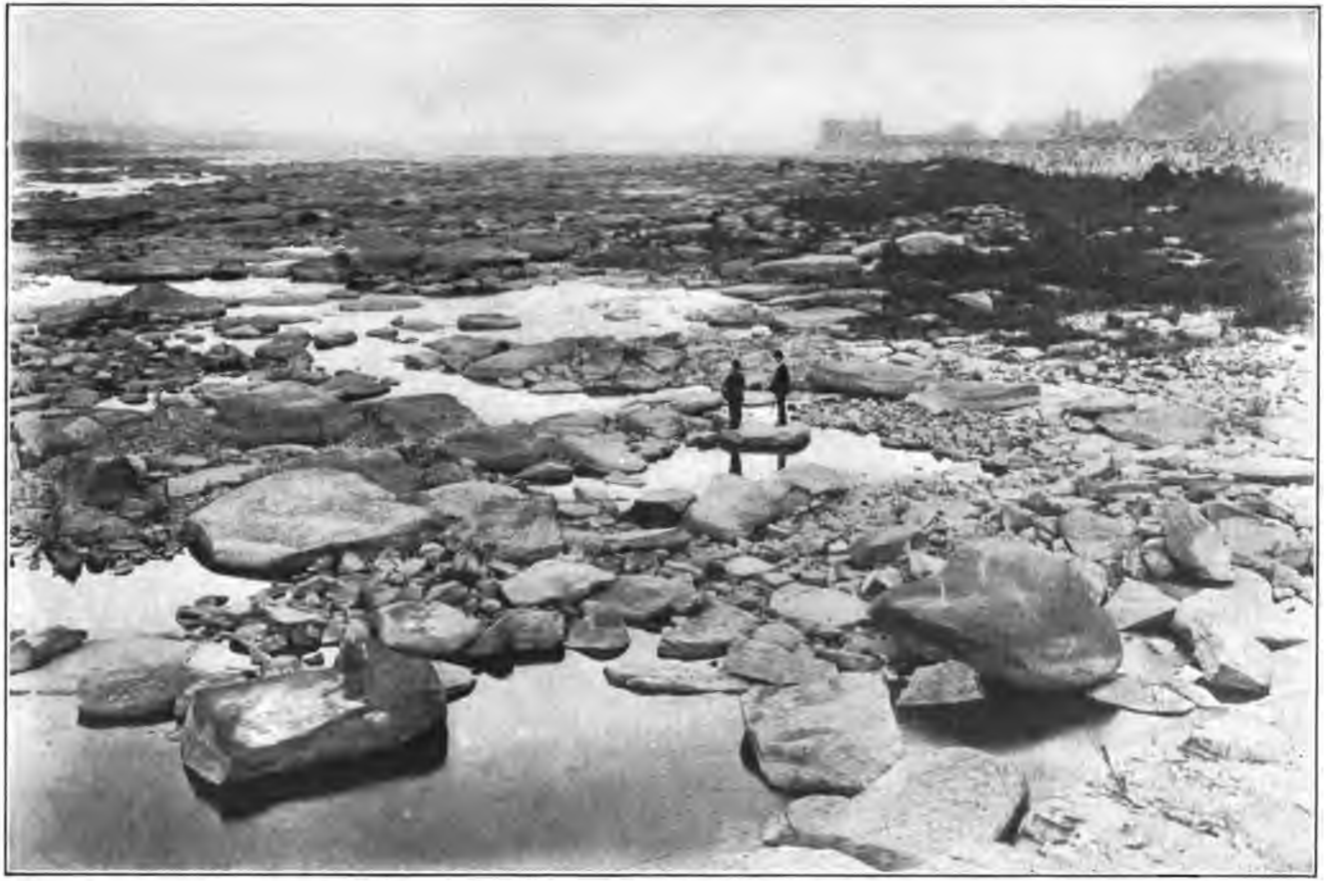
Showing Monthly Precipitation and Departure from Normal in the Three Principal Drainage Basins for 1904.

Month.	Delaware basin.		Susquehanna basin.		Ohio basin.	
	Deficiency in inches.	Excess in inches.	Deficiency in inches.	Excess in inches.	Deficiency in inches.	Excess in inches.
Janaury,	--------	0.20	--------	0.71	--------	0.40
February,	1.66	--------	0.80	--------	0.15	--------
March,	0.34	--------	--------	0.27	--------	1.69
April,	0.79	--------	--------	0.57	--------	0.90
May,	1.20	--------	0.32	--------	0.10	--------
June,	--------	0.43	--------	0.07	0.31	--------
July,	0.64	--------	--------	0.66	--------	0.21
August,	--------	2.16	0.80	--------	0.07	--------
September,	--------	1.20	0.05	--------	0.93	--------
October,	--------	1.01	0.65	--------	0.57	--------
November,	1.39	--------	2.22	--------	2.70	--------
December,	1.08	--------	1.05	--------	0.70	--------
Total deficiency for year,	2.30	--------	3.61	--------	2.33	--------

THE DROUGHT OF 1908.

The drought of 1908 first became noticeable in August and before the end of November it had been felt in all parts of the State with results probably more serious than those of any other such visitation Pennsylvania has received. Previous to August, although there had been a large deficiency of precipitation in June, and for three weeks in July, the ground storage, filled by an excess of about 5 inches of precipitation during February, March, April and May, had maintained stream and ground water flow. During the latter part of that month, however, the surface waters became noticeably low and in the next few weeks depreciated rapidly, reaching a minimum toward the end of September. Rains over most of the State on September 28th and 29th raised the streams somewhat, but the continued draft on the ground storage, and lack of rain in any appreciable amount until October 10th and 11th, again brought the surface and ground waters to a low stage. On the 10th and 11th of October, light rains ocurred, sufficient at some points to improve conditions a little; but between this date and October 24th, the streams generally reached stages approximately as low as in September. Sufficient precipitation to materially improve conditions did not occur until October 24th, when there were five days of more or less continuous precipitation. In November, the total precipitation was less than that during any of the previous months, and many of the streams again fell quite, or nearly, to the September minimum. Little rain or snow fell in the early part of December, and the condition of the streams was maintained generally at a very low stage through the month. The smaller creeks naturally showed the effect of the occasional rains by appreciable rises, but the larger rivers hardly felt their influence and remained quite uniformly close to the September minimum throughout the rest of the year.

As seen on Table No. 20, the precipitation was above the normal during February, March, April and May, January being slightly less than the average for that month, so that up to June 1st there had been an excess of precipitation of 5.30 inches, which, when considered with an excess of 2.67 inches during 1907, should have resulted in full reservoirs, saturated ground and subsoil and high ground water level. In June and for the first three weeks in July, came the first noticeable deficiency, broken on the 21st of July by heavy and disastrous thunder storms, heaviest where the lack of rain had been the greatest. These heavy storms caused an excess of precipitation in the Susquehanna basin for the month of August, and only small deficiencies over the rest of the State, but aided little in bettering stream conditions owing to the dryness of the soil, the requirements of growing vegetation, high temperature, and the character of the precipitation, which fell largely in heavy and destructive thunder storms, little water entering the ground to aid the springs and wells. The surprising feature is that by the 28th of September, when the accumulated deficiency of precipitation for the year had only reached about 0.5 of an inch, the surface waters had seemingly reached a minimum, not to be exceeded during the rest of the year, although followed by three months of deficiency in precipitation. This may be explained, however, by the fact that the ground water had been reduced by the four dry months preceding the last of September, the few rains during that period aiding little in replenishing it, while the rains of September 28th to 30th, October 10th to 11th, and October 24th to 30th, were long, soaking rains, which saturated the ground and came off gradually, their influence being felt over considerable periods, while had they been short, violent storms, similar to those of July, the beneficial effect upon the streams would doubtless have been less. If during the remainder of the year, following the period of low stream flow of the latter part of September, the precipitation had been normal, the condition would have occurred of exceptionally low stream stage, and restricted water supply, during a year which showed a total deficiency in precipitation for the State of only about one-half an inch. This drought, therefore, indicates the importance of rain during the summer months and seems somewhat at variance with the theory that a wet spring insures good stream flow in the summer and fall, and that summer rain is not essential to the streams. It also shows the importance of the character of the precipitation in maintaining stream discharge, the severe thunder storms of July, although bringing the precipitation for that month above or near the normal, having improved the stream flow but little, while the few, light, prolonged rains of September and October preserved it at about the September minimum through October and November. The State average precipitation for the year was 38.79 inches, the average deficiency being 3.98 inches, while the monthly excess of temperature exceeded the monthly deficiency by 13.4 degrees.



Susquehanna river at York Haven during the drought of 1908—The Power Company head race to the right.

TABLE NO. 21.

Table Showing Departure of Precipitation in 1908 from the Normal by Drainage Basins.

Month.	Delaware basin.		Susquehanna basin.		Ohio basin.	
	Deficiency in inches.	Excess in inches.	Deficiency in inches.	Excess in inches.	Deficiency in inches.	Excess in inches.
January,	0.50	--------	0.47	--------	0.68	--------
February,	--------	1.74	--------	2.13	--------	1.08
March,	0.41	--------	--------	0.53	--------	2.35
April,	0.33	--------	--------	0.23	--------	0.81
May,	--------	2.19	--------	2.45	--------	1.95
June,	1.69	--------	2.21	--------	1.70	--------
July,	0.06	--------	--------	0.96	0.34	--------
August,	0.38	--------	1.60	--------	1.39	--------
September,	1.77	--------	1.63	--------	2.09	--------
October,	1.05	--------	1.00	--------	2.01	--------
November,	2.37	--------	1.90	--------	1.91	--------
December,	0.80	--------	0.72	--------	0.18	--------
Total for year,	9.36	3.93	9.53	6.30	10.30	6.19
Total deficiency for year,	5.43	--------	3.23	--------	4.11	--------

It will be seen by Table No. 21 that the Susquehanna Basin experienced the least deficiency in precipitation, 3.23 inches, against 4.11 inches over the Ohio and 5.43 inches over the Delaware Basin, being equivalent to 8 per cent., 10 per cent. and 12 per cent. respectively. In the Susquehanna and Ohio Basins the spring precipitation was in excess of the normal, while in the Delaware basin, March and April showed deficiencies, so that it is to be expected that streams would be lowest in the Delaware and least affected in the Susquehanna basin. The greatest deficiency in precipitation for the year was recorded at Kennett Square, Chester county, where 15.79 inches, or 31.5 per cent. less than the normal rain fell; at Erie, there was 11.83 inches, or 30.7 per cent. less than the normal, and at Seisholtzville, Berks county, 11.29 inches, or 22.4 per cent. less than the normal was recorded, the least actual precipitation recorded in the State being at Erie, 26.72 inches.

Streams reached stages lower in some instances than hitherto recorded, while springs and wells, which were said never to have failed before, went dry, and municipal and industrial storage reservoirs became exhausted. In fact there is no previous record of such a general shortage in the available water supply of the state. In order to determine accurately the discharge of streams during such periods, and their value for supply purposes, extensive stream flow measurements were made by the Commission during this period. A total of 160 measurements were made during August, September and October, covering 124 streams. The subsequent statements and data presented are based upon these measurements and upon the results of an extensive census, including nearly every community supplied with water in Pennsylvania, to determine the effect of the drought upon water supplies.

The following table shows the minimum stage of important streams during the 1908 drought, compared with the available data for previous droughts.

TABLE NO. 22.

Minimum Stage Reached During Drought of

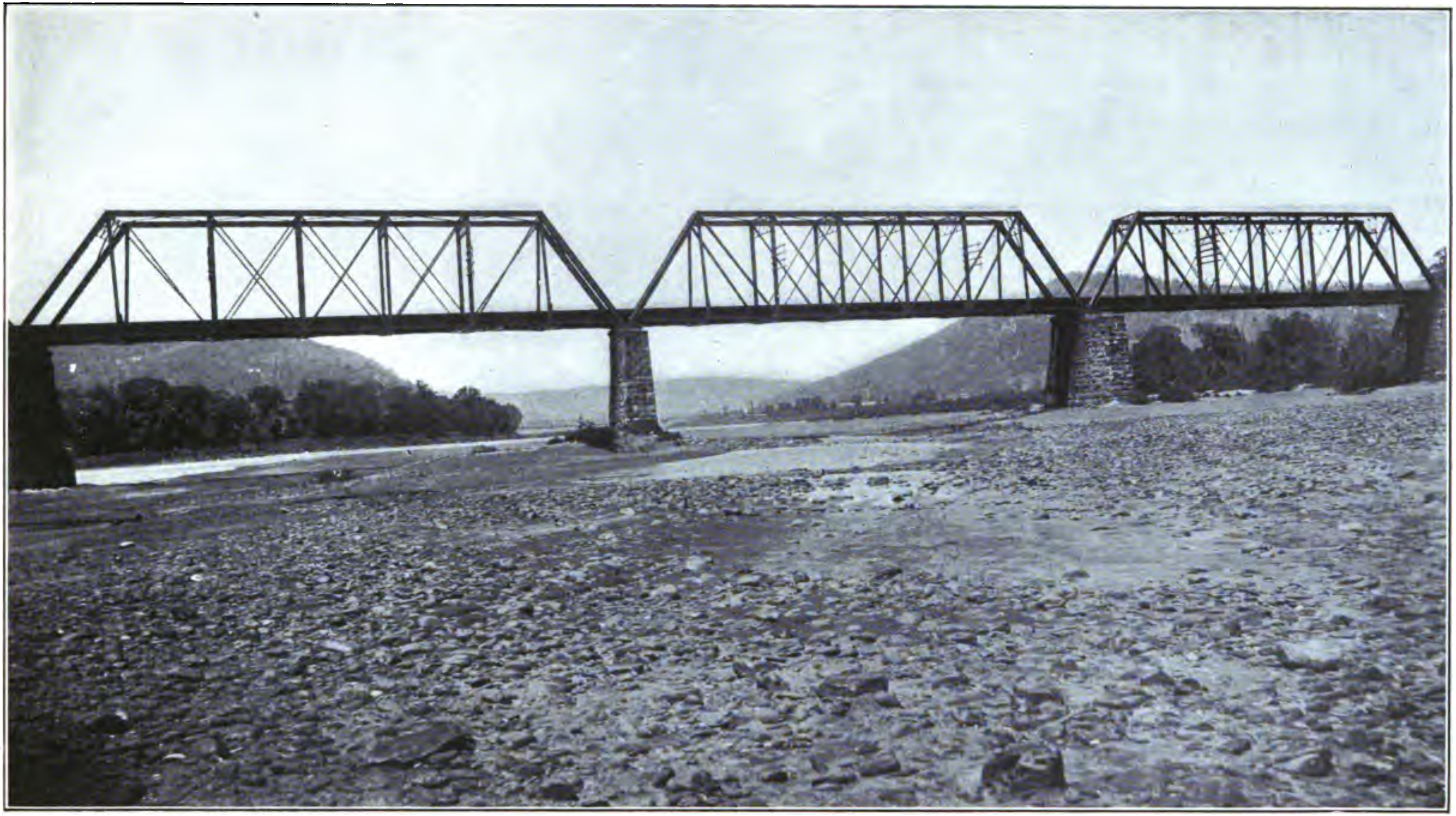
Name of Stream.	1881	1891	1892	1895	1900	1904	1908
Delaware river at Port Jervis,		—0.8				+0.4*	—1.1
Susquehanna river at Harrisburg,				+0.1	—0.04	+1.3	+0.2
North Branch at Wilkes-Barre,					+2.1	+3.1	+2.0
West Branch at Williamsport,				—0.2	+0.1	+0.2	+0.2
Allegheny river at Freeport,	—0.6			+0.4	+0.2	+0.9	+0.2
Youghiogheny river at West Newton,			—0.3	—0.1	—0.1	+0.0	—0.2

*Estimated.

NOTE.—The construction of navigation dams in the Ohio and Monongahela rivers makes it impossible to present data for those streams.

These data are liable to error due to the silting up of stream beds or other changes in cross-section, for if deposits have raised the bed the same quantity of water now passing will be recorded at a higher gage height than before the deposition was made. In other words, a gage reading of 0.5 today might mean that no more water was passing than a reading of 0.3 years ago. It is as yet not possible to state to what extent this element is present, but it is known that it affects certain records.

The Delaware river at Port Jervis, N. Y., reached a point 0.3 of a foot lower, and at Trenton, 0.2 of a foot lower than previously recorded. The Susquehanna river at Wilkes-Barre reached a stage of 0.1 of a foot below the lowest previously recorded stage, of October 7th and 8th, 1900; Little Wysox and Sugar creeks, important tributaries of the North Branch, were practically dry; the West Branch at Williamsport remained 0.4 of a foot above the low water mark of 1895, and but 0.1 of a foot above that of September, 1900, while at Harrisburg the Susquehanna river reached a point only 0.24 of a foot above the lowest recorded stage of September 28th and 29th, 1900. The Allegheny river at Freeport, 25 miles above Pittsburg, remained 0.8 of a foot above the low water record of September 26th, 1881, and September 10th, 1886. The Conemaugh river was dry between the intake of the Cambria Steel Company, near South Fork, and the mouth of Stony creek, at Johnstown. The Youghiogheny river at West Newton reached a point only 0.1 of a foot above the low water mark established September 14th, 1892; the Monongahela river was



North branch Susquehanna River, near Wilkes-Barre, low water of 1908.

also very low, while two of its important tributaries, Ten Mile creek and Dunkard creek, in Washington and Greene counties, were dry, as was Laurel creek, a large tributary of the Youghiogheny river.

Table No. 23 shows the measured flow of the large rivers of the State at or near the height of the drought. The Commission maintains permanent gaging stations at most of these points.

TABLE NO. 23.

Showing Minimum Flow of Principal Rivers of Pennsylvania at or near the Height Drought of 1908.

Stream.	Station.	Date, 1908.	Discharge in cubic feet per second.	Drainage area in square miles.	Run-off in second-feet per square mile.
Delaware river,	Port Jervis,	Sept. 20,	225.7	3,376	0.07
Delaware river,	Riegelsville,	Sept. 15,	1,409.5	6,500	0.22
Lehigh river,	South Bethlehem,	Sept. 14,	494.2	1,274	*0.39
Schuylkill river,	Port Clinton,	Sept. 22,	69.9	334	*0.21
North Branch, Susquehanna,	Danville,	Sept. 15,	980.9	11,100	0.09
Lackawanna river,	Scranton,	Sept. 23,	55.8	206	*0.27
West Branch, Susquehanna,	Renovo,	Sept. 10,	188.5	3,350	0.06
West Branch, Susquehanna,	Williamsport,	Sept. 7,	614.5	5,640	0.11
Susquehanna river,	Harrisburg,	Sept. 12,	3,216.6	24,030	0.13
Juniata river,	Newport,	Seut. 10,	651.6	3,480	0.19
Allegheny river,	Tionesta,	Sept. 28,	374.6	3,718	0.10
Allegheny river,	Tarentum,	Sept. 25,	713.0	11,050	0.07
Allegheny river,	Kittanning,	Sept. 25,	847.2	8,690	0.10
Kiskiminetas river,	Avonmore,	Sept. 25,	68.5	1,683	0.04
Clarion river,	Clarion,	Sept. 26,	119.5	922	0.13
French creek,	Carlton,	Sept.	64.0	896	0.07
Monongahela river,	Pittsburg,	Sept.	325.0	7,329	**0.04
Youghiogheny river,	Confluence,	Sept. 25,	36.1	1,000	0.04
Youghiogheny river,	West Newton,	Sept. 28,	51.0	1,582	0.03
Ohio river,	Beaver Dam, No. 6,	Sept. 24,	1,272.0	22,300	0.06
Beaver river,	Beaver Falls,	Sept. 23,	200.0	3,000	0.07
Mahoning river,	Mouth,	Sept. 23,	72.8	1,070	0.07

*Receives considerable mine water.
**Approximated by substraction of the flow of other tributaries from that of the Ohio river.

The action of streams draining limestone areas, during the drought, was particularly worthy of notice. Of these streams, all of which lie east of the crest of the mountains, perhaps the most important are Bald Eagle creek, Spruce creek, Frankstown Branch of the Juniata river, Conodogwinet creek, Codorus creek, Yellow Breeches creek, Swatara creek, Quittapahilla creek, Conestoga creek, Tulpehocken creek, Maiden creek, Lehigh river and Monocacy creek. While the major tributaries of the Susquehanna and Ohio Basins were going dry, or reaching rates of flow considerably under 0.1 of a second-foot per square mile of tributary drainage area, and even under 0.05 of a second-foot, these streams were found to be flowing from 0.2 to 1.0 second-foot per square mile, as shown by the following table.

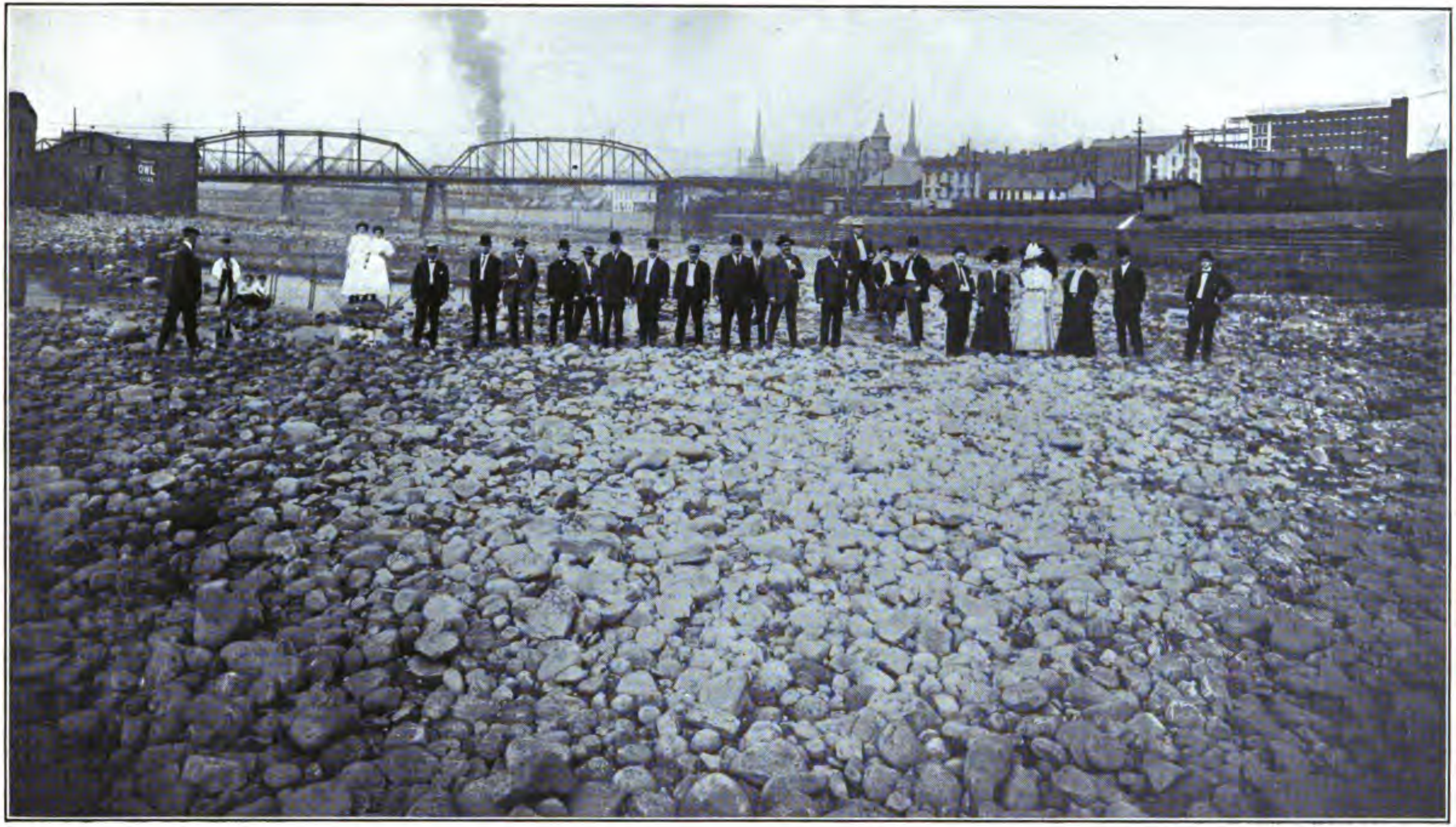
TABLE NO. 24.

Run-Off During Drought of 1908 of Streams Whose Drainage Basins Contain Considerable Areas of Limestone.

Stream.	Date, 1908.	Discharge in cubic feet per second.	Drainage area in square miles at point of measurement.	Run-off in cubic feet per second per square mile.
Bald Eagle creek,	Sept. 9,	304.7	782	0.39
Spruce creek,	Sept. 9,	63.6	93	0.68
Conodogwinet creek,	Sept. 11,	188.3	481	0.39
Yellow Breeches creek,	Sept. 11,	219.3	220	1.00
Codorus creek,	Sept. 15,	53.2	268	0.20
Swatara creek,	Sept. 12,	124.9	440	0.28
Conestoga creek,	Sept. 20,	62.2	310	0.21
Maiden creek,	Sept. 21,	80.4	217	0.37
Tulpehocken creek,	Sept. 21,	91.9	215	0.43
Lehigh river,	Sept. 14,	494.2	1,274	0.39
Monocacy creek,	Sept. 14,	28.8	52.2	0.55
Spring creek,	Sept. 12,	4.6	11.6	0.40
Kisacoquillas creek,	Sept. 10,	32.7	174	0.19

It may be that the heavy spring rains of 1908 were responsible in some measure for the well maintained flow of the limestone streams, for they draw on large volumes of subterranean storage, sometimes fed from areas which, according to surface topography, should drain elsewhere. Had the spring months shown a deficiency instead of an excess of precipitation, this storage would have been lower and have come nearer exhaustion during the dry summer. At the same time the wet spring seems to have had less effect upon the non-limestone streams as their storage is limited. In some instances it was stated by millers that certain of the limestone creeks had been known to be lower, while in most instances the other creeks were said to be as low as, or lower than, heretofore known.

The measurements indicated a noticeable difference between the flow of streams whose catchment areas are well forested and those whose basins are not, for determinations made at practically the same period of the drought, when rainfall conditions had been fairly uniform over the State, showed that streams of the former class were usually maintaining the better flow. The following table shows the rate of flow, at the height of the drought, of several important streams whose water sheds have been quite largely deforested.



Low water on Youghiougheny river at Connellsville, drought of 1908.

TABLE NO. 25.

Run-Off During Drought of 1908 of Streams Whose Drainage Basins are Largely Deforested.

Stream.	Date, 1908.	Discharge in cubic feet per second.	Drainage area in square miles at point of measurement.	Run-off in cubic feet per second per square mile.
Mahanoy creek,	Oct. 24,	32.6	133	*0.25
Shamokin creek,	Sept. 16,	21.8	165	*0.13
Catawissa creek,	Sept. 26,	6.0	131	0.05
Chillisquaque creek,	Sept. 16,	3.0	100	0.03
Wapwallopen creek,	Sept. 25,	7.2	49	0.15
Wyalusing creek,	Sept. 24,	3.7	200	0.018
Kiskiminetas river,	Sept. 25,	68.4	1,683	0.04
Black Lick creek,	Sept. 24,	6.6	403	0.016
Loyalhanna creek,	Sept. 24,	10.7	300	0.036
Turtle creek,	Sept. 24,	14.5	145	0.10
Dunbar creek,	Nov. 19,	2.3	37	0.06
Raccoon creek,	Sept. 27,	1.0	190	0.005
Connoquenessing creek,	Sept. 23,	11.0	434	0.027
Towanda creek,	Sept. 24,	8.6	220	0.04
Ten Mile creek,	Sept. 26,	0.0	350	0.00
Dunkard creek,	Sept. 26,	0.0	224	0.00

*These streams receive considerable mine drainage from the anthracite coal region.

Table No. 26 shows the rate of flow of several streams in the remaining forested sections of the State. In both tables Nos. 25 and 26 limestone streams and streams from the once glaciated region have been omitted.

TABLE NO. 26.

Run-Off During Drought of 1908 of Streams Whose Drainage Basins Contain Considerable Forest Areas.

Stream.	Date, 1908.	Discharge in cubic feet per second.	Drainage area in square miles at point of measurement.	Run-off in cubic feet per second per square mile.
Analomink creek,	Sept. 16,	9.2	29.5	0.31
Bushkill creek,	Sept. 19,	8.1	126	0.064
Little Bushkill creek,	Sept. 18,	4.0	40	0.10
Rapid run,	Sept. 17,	7.7	25	0.31
Tuscarora creek,	Sept. 10,	23.4	252	0.09
Big Loyalsock creek,	Oct. 22,	43.3	494	0.09
Pine creek,	Oct. 21,	67.3	846	0.08
Little Pine creek,	Oct. 21,	17.0	172	0.10
Lick run,	Sept. 9,	3.8	40	0.095
McElhatten run,	Sept. 9,	5.9	20	0.34
Tionesta creek,	Sept. 28,	39.7	455	0.09
Brokenstraw creek,	Sept. 28,	45.2	300	0.15
Driftwood Branch of Sinnemahoning creek,	Sept. 11,	11.2	314	0.04
McMichaels creek,	Sept. 16,	23.8	102	0.23

The streams which drain the section of the State which was once covered by the glacier, and whose sheds, therefore, contain numerous lakes, ponds and swamps, and whose surface cover consists in part of glacial drift, gravel and sand areas, maintained, as a rule, rates of discharge fairly comparable to well forested watersheds, as shown in table No. 27.

TABLE NO. 27.

Run-Off During Drought of 1908 of Streams Whose Drainage Basins Lie in the Once Glaciated Area.

Stream.	Date, 1908.	Discharge in cubic feet per second.	Drainage area in square miles at point of measurement.	Run-off in second-feet per square mile.
Brokenstraw creek,	Sept. 28,	45.2	300	0.15
Oil creek,	Sept. 27,	39.3	305	0.13
French creek,	Sept. 27,	64.0	896	0.07
Shenango river,	Sept. 23,	29.0	765	*0.04
Neshannock creek,	Sept. 23,	41.3	245	0.17
Slippery Rock creek,	Sept. 23,	45.6	440	0.10
Lackawaxen river,	Sept. 22,	33.2	300	0.11
Bushkill creek,	Sept. 19,	8.4	126	0.07

*The water of this stream is in dry weather used about six times by industries, and considerable was dissipated in this way, it is presumed.

Reports do not indicate that crops were greatly damaged during the summer, due probably to the fact that the wheat, oats and hay were harvested before the height of the dry spell, while the corn and tobacco crops were well advanced. The agriculturalist suffered the most through the material lowering of the stream flow and the ground water level in September, October and November, and many farmers were forced to haul water for domestic and farm use.

Municipal water supply systems suffered in all parts of the State, the most trouble being experienced by municipalities located in regions of great industrial activity, where industries utilize available streams, limiting the supplies for municipal purposes. Thus in the anthracite coal region and on both slopes of the Alleghenies in Blair and Cambria counties, communities were seriously affected. It was necessary to warn users quite generally over the State to be frugal in the use of the water, street and lawn sprinkling was prohibited, and reports indicate that from 25 per cent. to 50 per cent. reduction in consumption was thus effected, in connection with the caution that consumers be as saving as possible in the use of water for all purposes. In fewer instances the time of using water was limited to a certain period each day, while in a few cases the supply became exhausted. In numerous instances, in order to prevent the entire failure of the supply, resourse was taken to temporary supplies, thus at Johnstown the Cambria Steel company, through a temporary connection, supplied water from its Hinkston run reservoir to the city for many weeks; at Altoona the municipal supply becoming depleted, the Allegheny Water Co., which supplies suburbs of the city, made a connection with the city mains, furnishing Altoona with over one million gallons per day for an extended period. The city of Shenandoah, with its 30,000 population, located in the anthracite coal fields in Schuylkill county, suffered perhaps as much as any community in the State, being dependent upon a number of streams for its water supply, and relying on storage to tide over periods of drought. The reservoirs of both systems supplying the city gave out during September and a limited quantitiy was furnished for a short time each day. The Girard Water Company, which supplies collieries in the vicinity of Shenandoah, furnished some water to the city during this period, but this company itself was short and so could not offer effectual aid. The borough of Cresson, population 1,500, lying in Cambria county, just west of the summit of the Allegheny mountains, was practically without water for many weeks, although there are 8 water companies incorporated for this district, two of which, belonging to the railroad supply system, had their pipe lines full continually and supplied water to shops and locomotives. Canonsburg, Washington county, was entirely without water for an extended period. At other points temporary intakes were placed in streams and at springs to reinforce the regular systems. Reports from all parts of the State indicate that general shortage existed in small towns without water supply and in rural districts, for the ground water level, late in the fall, became exceedingly low and wells dried up in great numbers. The small villages whose inhabitants were dependent upon wells seem to have suffered considerably more than towns which were served by water supply systems. The country districts generally were more affected than the urban districts.

Of the 485 water supply systems of which data as to the effect of the drought were obtained, 152 or 31 per cent. reported that a shortage existed or was prevented by temporary measures. Of the 11 systems reporting from Centre county, 5 ran short; of 19 reporting from Cambria county, 14 were short, and of the 10 reporting from Blair county, 6 were short, etc. As a result, extensions and additions to systems are being considered in many parts of the State.

A noticeable feature of the drought, and one the Commission feels should be placed before the public, was the general water shortage at towns and cities along the line of the Pennsylvania Railroad, extending from the foot of the mountains on the east at Altoona, westward and down the valley of the Conemaugh river to and beyond Johnstown. Along this line the railroad supply from its new system proved ample, its mains carrying an abundance of good water through municipalities whose local systems were inadequate and whose population and industries suffered as a consequence.

Numbers of the larger industries receive their water through systems owned or controlled by the industrial company, and obtained entirely for this purpose, being dependent upon no municipal system. Many such supplies proved inadequate during the drought, and as a result water had to be obtained by hauling in wagons or in tank cars, or through temporary pipe lines, and in numerous cases the works were shut down. Certain industries, which use water extensively in the process of manufacturing, such as pulp and paper mills, glass works, tanneries, coal washeries, coke ovens, etc., were naturally the most affected. Blast furnaces and steel works, which are heavy consumers of water, have usually been built along or near large rivers, obtaining their water therefrom, and were not in so many instances inconvenienced.

Reports received from 14 of the 40 coal district inspectors of the Department of Mines, after inquiry made for the purpose, showed considerable losses in these regions due to lack of water. Very generally mine water was used in the boilers owing to inadequacy of the usual sources of water supply, resulting in heavy expense for boiler repairs, or in the application of chemicals to prevent boiler injury. In numerous other cases temporary pipe lines were laid and pumping plants set up, to reinforce the usual sources of supply. In these 14 districts there was a loss reported during shut downs or times of restricted output, occasioned by lack of water, of 150,500 men days and a loss of money expended for boiler repairs, chemicals, new pipe lines, hauling water, pumping from temporary intakes, drilling wells, etc., directly attributed to the drought, of $42,000, while in addition many mines reported that it was not possible to state definitely the expenditures for these purposes.

Occurring during a year of marked business depression, when industrial establishments were using less water than in the year previous, the shortage in many towns and cities, and at numerous industrial plants, was less keenly felt than had business conditions been normal. In certain instances, where supplies proved adequate, it was stated that had the industrial consumption equalled that of 1907, the supply would have unquestionably fallen short. Two large steel plants on the Shenango river use, when running at full capacity, over two times as much water as was flowing in this stream during September, October and November; but these plants were either shut down or running at low capacity on account of the dull times, and obtained sufficient water.

It would seem from the above discussion that the normal precipitation in some parts of Pennsylvania is little more than sufficient for the requirements, as shown by the very decided restrictions caused by a seemingly small deficiency from the normal precipitation. A given deficiency in the precipitation is today of more importance than formerly, for the consumption for domestic and industrial purposes is increasing rapidly, while at the same time the proportion of run-off to rainfall tends in many parts of the State to decrease yearly, owing probably to changed watershed conditions; so that the available balance between consumption and supply is growing less, and in the case of some watersheds, has become exhausted. Any factor tending to reduce the yield from a given watershed affects, therefore, a proportionately greater reduction in this available balance. The deficiency in precipitation up to October 1st, 1908, seems small to have been the whole cause of the September period of minimum stream stage, and an additional cause may have been the abnormally high temperature during June, July and September, causing high evaporation, which element seems this year to have been of more than usual importance in the water supply problem, owing to the depreciated available balance. The droughts of 1895, 1900, 1904 and 1908 have taught us that with our fairly equal seasonable distribution of precipitation a seemingly small departure from the normal, either in distribution or total precipitation, has a great effect upon the run-off of streams and the available water supply. To meet these conditions it will be necessary either to restrict the use of water and control its waste, or to store it in wet seasons for use when the stream flow depreciates.

As in the case of other natural resources, the water supply should be used to its fullest, but unnecessary waste should be prevented. The State of New Jersey has attempted to prevent the waste of water by levying a tax of from one to ten dollars per million gallons for all water used for the supply of municipalities over and above a rate of 100 gallons per capita per day. Similar methods are applicable to industrial or commercial water supplies.

CHAPTER V.

FLOODS IN 1908.

In the report for 1907 data were presented relative to the principal freshets on the rivers of the State up to that date; this chapter will, therefore, be devoted to a discussion of the floods occurring during the year 1908.

The streams of the Commonwealth experienced two periods of high water during the winter of 1908, one in February, and one in March, the former being a sudden rise from an ordinary low winter stage, when the streams were quite generally frozen, and a fall almost as sudden, lasting at most points, only five days; while the latter covered a longer period, during which several crests were reached. The February freshet was general over the State, while that of March was not important in the Delaware Basin. In neither period did the larger streams, except the Kiskiminetas and Juniata rivers, reach unusual freshet heights, while during both periods the smaller streams rose in violent floods. Little damage was done in the main river valleys, but along the secondary streams considerable monetary losses resulted through the destruction of bridges, railroad embankments and the other usual accompaniments of high water, while several lives were lost by reason of the extraordinary height and suddenness of the rises in small streams. It is worthy of special note that in both February and March the Allegheny river at Freeport exceeded the stage reached during the flood of March, 1907, when the rivers at Pittsburg, 24 miles below, reached a record flood stage.

Although unusual heights were not reached at most points on the large rivers a study of these freshets sheds light upon the flood conditions in the State, for it was determined that extraordinary conditions were not required to cause unprecedented high water in many of the secondary streams, and that the retardation of the flow of certain large tributaries reduced the height of the crest in the rivers below. The February flood was checked by a fortunate fall in temperature which stopped further melting of snow and turned the rain into snow, preventing greater heights and damage. The general prevalence of the February storm over both the Allegheny and Monongahela watersheds was largely responsible for the high stage reached at Pittsburg. Favorable conditions existed for great floods both in February and March; considerable snow lay on the ground, sudden and sharp rises in temperature followed by general rains occurred, but each time climatic conditions changed opportunely and the floods were checked. The flood of February was more general than that of March, and preceding it, many of the rivers were frozen and the water low, while both freshets assumed the greatest proportions on the western rivers, and were less in evidence in the Delaware Basin.

In connection with the compilation of flood data for the report for 1907, it was found that the gage heights of many streams had been observed for long periods, but that the knowledge of their discharge was much more limited, and that such information during high stages was particularly meagre. To increase this knowledge preparations were made in the fall of 1907 to take extensive stream flow measurements during the freshets of 1908, and several new stations were established and arrangements made for co-operation of other State, City and Federal organizations in order that a large temporary force might be available, with the result that high stage discharge measurements were made at many points. The results obtained on the Delaware and Juniata rivers are particularly interesting, in that stations had been maintained at Lambertville and Newport respectively for a number of years, but no actual discharges during high stages had been measured previous to this year, the discharges during the October, 1903, flood on the Delaware river and during that of March, 1902, on the Juniata river having been based upon measurements at much lower stages. The data obtained by the Commission's measurements increased by 25 per cent. the previously estimated maximum discharge of the Delaware river at Lambertville, and reduced by considerably more than 100 per cent. that of the Juniata river at Newport. On the Kiskiminetas river, an important stream in the flood problem at Pittsburg, a very satisfactory and valuable set of readings was obtained, while new stations were established and measurements made at Clarion, on the Clarion river, and at Carlton, on French creek. High stages were also measured at Williamsport on the West Branch, Harrisburg on the Susquehanna river, Bethlehem on the Lehigh river, Huntingdon and Hawns Bridge on the two branches of the Juniata river, Confluence on the Youghiogheny river, Aspinwall on the Allegheny river, East Pittsburg on Turtle creek, Lochiel on Spring creek, Harrisburg on Paxton creek, etc. Spring creek, a small stream passing through the Harrisburg Park System and draining 11.6 square miles of rolling, highly cultivated, nearly deforested country, was measured during what was said to have been the highest water known, which measurement shows that at the crest of the flood it was discharging at the rate of 238 second-feet per square mile of watershed, being the greatest rate of run-off obtained by this Commission. The run-off over the 48.6 square miles of the South Fork of the Conemaugh river during the flood of June 1, 1889, was estimated to be 200 second-feet per square mile, while that of Burgoon run above the Altoona reservoirs, drainage area 8.5 square miles, was placed at 400, but neither of these figures was obtained by actual measurement during the freshet. No measurements were made at Kittanning as discharges were measured up to high stages during the flood of 1905, while none were made on the North Branch of the Susquehanna river as that stream did not rise above heights previously measured.

During the flood periods of 1908 a total of 58 discharge measurements were made at the gaging stations of the Commission, distributed as shown in Table No. 28, which also shows the date and discharge, together with the previous maximum gage height recorded.

TABLE NO. 28.

Discharge Measurements Made in Freshet Period of 1908.

Station.	Stream.	Date.	Gage height.	Discharge.	Previous maximum gage height at station.
Lambertville, --------	Delaware river, ------	Feb. 16	13.6	112,000	24.5 (1903).
Lambertville, --------	Delaware river, ------	Feb. 16	13.8	114,000	No record.
Riegelsville, ----------	Delaware river, ------	Feb. 17	17.1	80,600	No record.
Riegelsville, ----------	Delaware river, ------	Feb. 17	16.05	75,300	No record.
Riegelsville, ----------	Delaware river, ------	Feb. 18	15.2	66,600	No record.
Riegelsville, ----------	Delaware river, ------	Feb. 18	11.15	38.900	No record.
Riegelsville, ----------	Delaware river, ------	Feb. 18	10.87	37,300	No record.
Riegelsville, ----------	Delaware river, ------	Feb. 19	9.16	28.200	No record.
South Bethlehem, ---	Lehigh river, ---------	Feb. 17	---------	---------	No record.
South Bethlehem, ---	Monocacy creek, -----	Feb. 17	---------	---------	No record.
Harrisburg, ---------	Susquehanna river, --	Mar. 17	14.63	263,869	25.6 (1894.)
Williamsport, -------	West Branch, --------	Feb. 16	16.32	*99,120	21.10 (Mar., 1902.)
Williamsport, -------	West Branch, --------	Mar. 20	16.84	94,057	21.10 (Mar., 1902.)
Newport, -----------	Juniata river, --------	Feb. 16	13.70	*39,945	25.30 (Mar., 1902.)
Newport, -----------	Juniata river, --------	Feb. 17	10.80	27,351	25.30 (Mar., 1902.)
Newport, -----------	Juniata river, --------	Feb. 17	10.20	*24,767	25.30 (Mar., 1902.)
Newport, -----------	Juniata river, --------	Mar. 9	12.58	35,331	25.30 (Mar., 1902.)
Newport, -----------	Juniata river, --------	Mar. 19	19.15	73,000	25.30 (Mar., 1902.)
Huntingdon, --------	Frankstown branch, --	Feb. 18	4.99	2,197	14.00 (Dec., 1901.)
Huntingdon, --------	Frankstown branch, --	Mar. 9	7.65	7,899	14.00 (Dec., 1901.)
Huntingdon, --------	Frankstown branch, --	Mar. 10	6.85	6,530	14.00 (Dec., 1901.)
Huntingdon, --------	Frankstown branch, --	Mar. 10	6.48	5,866	14.00 (Dec., 1901.)
Huntingdon, --------	Frankstown branch, --	Mar. 19	12.70	27,854	14.00 (Dec., 1901.)
Huntingdon, --------	Frankstown branch, --	Mar. 20	9.50	12,985	14.00 (Dec., 1901.)
Huntingdon, --------	Frankstown branch, --	Mar. 20	8.70	10,378	14.00 (Dec., 1901.)
Hawns Bridge, ------	Raystown branch, ----	Feb. 18	6.48	3,798	No record.
Hawns Bridge, ------	Raystown branch, ----	Mar. 10	9.35	10,045	No record.
Hawns Bridge, ------	Raystown branch, ----	Mar. 20	12.80	19,830	No record.
Avonmore, ----------	Kiskiminetas, ---------	Mar. 3	13.70	19,205	30.25 (March, 1908.)
Avonmore, ----------	Kiskiminetas, ---------	Mar. 3	12.87	16,959	30.25 (March, 1908.)
Avonmore, ----------	Kiskiminetas, ---------	Mar. 3	12.41	15,685	30.25 (March, 1908.)
Avonmore, ----------	Kiskiminetas, ---------	Mar. 4	10.80	11,542	30.25 (March, 1908.)
Avonmore, ----------	Kiskiminetas, ---------	Mar. 4	10.38	10,488	30.25 (March, 1908.)
Avonmore, ----------	Kiskiminetas, ---------	Mar. 4	10.14	9,884	30.80 (March, 1908.)
Avonmore, ----------	Kiskiminetas, ---------	Mar. 4	9.85	9,634	30.25 (March, 1908.)
Avonmore, ----------	Kiskiminetas, ---------	Mar. 5	9.91	9,658	30.25 (March, 1908.)
Avonmore, ----------	Kiskiminetas, ---------	Mar. 5	9.85	9,398	10.25 (1905.)
Confluence, ----------	Youghiogheny, -------	Feb. 16	9.10	8,850	30.25 (March, 1908.)
Confluence, ----------	Laurel Hill creek, ----	Feb. 16	6.73	1,940	7.65 (1905.)
Confluence, ----------	Laurel Hill creek, ----	Feb. 17	3.74	960	7.65 (1905.)
Confluence, ----------	Casselman river, -----	Feb. 16	10.20	8,900	10.4 (March, 1905.)
Confluence, ----------	Casselman river, -----	Feb. 16	6.74	5,560	10.4 (March, 1905.)
Confluence, ----------	Casselman river, -----	Feb. 17	7.73	3,320	10.4 (March, 1905.)
East Pittsburg, -----	Turtle creek, ---------	Feb. 15	5.52	2,930	10.7
Clarion, -------------	Clarion river, ---------	Mar. 20	6.85	14,277	
Carlton, -------------	French creek, ---------	Mar. 19	8.35	7,170	No record.

*Float measurement.

The following data concerning the two freshet periods of the winter of 1908 were obtained from the above measurements, and from the records of the observers of the Commission and of the United States Weather Bureau.

FRESHET OF FEBRUARY.

The first general high water period in 1908 extended from February 14th to 18th, for during December and January the freshets in some of the secondary streams, caused by local rains and thaws, affected the rivers only slightly. During January and the early part of February there were exclusively snows, averaging probably 10 inches in depth over much of the State, and the rivers were nearly all frozen. On February 12th came a sharp rise in temperature in the west, followed in the east by a similar rise on the 13th, and accompanied generally by steady rains lasting from the 13th to the 15th. Ordinarily such a rain as this, uniform in intensity and averaging 1.15 inches over the State, would hardly have caused appreciable rises in the larger streams; but the frozen condition of the ground, and the large quantity of melting snow, caused a sudden and simultaneous rise. After the discharge of this rain and melted snow there remained little water to come out of the smaller creek valleys, the rain having stopped abruptly on the 15th or morning of the 16th, and the weather having turned cold, preventing further melting of the snow. Moreover, the water coming into the large rivers from their lower tributaries was carried away before the maximum arrived from above.

The rivers at Pittsburg came closer to previous record height than any other large streams, probably because high water from the lower Allegheny and Monongahela rivers arrived there almost at the same time and similar rain, snow and temperature conditions existed over both their basins. Had not this been the case, and had the Allegheny valley alone been subjected to this sudden rise in temperature and precipitation, the Ohio below Pittsburg would have been called upon to carry off only the flood flow of one stream. The Allegheny river at Freeport was at higher stage in February, 1908, than at the time of the record flood at Pittsburg of March 15th, 1907, but fortunately the Monongahela river was much lower in 1908 than in 1907.

On the Susquehanna river the flood water from Penns creek, Shermans creek, Juniata river, Conestoga, Swatara, Conodogwinet and Codorus creeks passed out before the crest from the West Branch arrived, while that from the North Branch arrived many hours behind the West Banch maximum. On the Delaware river the flood water from the Lehigh river was out before that from the two branches in New York and from the Lackawaxen river got down to Easton. Had there been, however, extensive rains and continued high temperature after the 15th, the water coming down from above would have met more water from the lower tributaries and a greater flood would have occurred.

TABLE NO. 29.

Average Temperature and Precipitation by Drainage Basins—February 11 to 15, 1908.

Basin.	Average temperature, Feb. 11.	Average temperature, Feb. 15.	Average rise.	Average total precipitation in inches.	Average snow on ground.
Delaware basin,	25.1 °	48.3 °	23.2 °	1.13	
Susquehanna basin,	21.6 °	43.8 °	22.2 °	1.03	
Ohio basin,	34.3 °	42.2 °	7.9 °	1.17	
Potomac basin,	30.75°	38.75°	8.0 °	1.31	
Erie basin,	33.5 °	42.0 °	8.5 °	1.12	
Average of State,	29.0 °	43.0 °	14.0 °	1.15	8 to 12 in.

Table No. 29 shows the average temperature before and after the rain, the average rise in temperature, the average total rainfall and the average depth of snow melting in each drainage basin. The maximum rainfall was at Parkers Landing, Armstrong county, on the Allegheny river, where there was a precipitation of 2.34 inches, 0.6 of which fell on the 16th and 17th in the form of snow. The prevailing temperatures preceding the flood were higher in the west than in the east, and the precipitation continued over the 16th, and in some cases to the 17th, in the form of snow in the west, while at nearly every station in the Susquehanna and Delaware Basins it stopped abruptly with the fall in temperature on the 15th. At practically every station the greatest precipitation was on the 15th, showing the exceeding uniformity of the conditions over the State. This table shows that the greatest rainfall was over the Potomac, and the least over the Susquehanna Basin. The greatest rise in temperature was over the Delaware Basin, that over the Susquehanna was one degree less, while over the Ohio it was the least. Furthermore, this table indicates that the average precipitation of all the stations was only 1.15 inches for three or four days of rain, while the melted snow may have been equivalent to 1.00 to 1.25 inches of rain; so that the run-off was seemingly of nearly equal parts rain and melted snow.

Table No. 30 shows the daily stages of the streams at points at which such records are kept, arranged by drainage basins. The height given is usually that at about 8 a.m., while at some points it is the average of A. M. and P. M. readings. Where carefully observed, the hour of the maximum height reached is shown.

TABLE NO. 30.

River Stages During February Freshet.

OHIO BASIN.

Station.	Date.									Flood stage.	Previous maximum.
	12	13	14	15	16	17	18	19	20		
Allegheny.											
Warren,	1.2	1.6	4.0	12.2 6 P. M.	11.0	9.7	8.3	7.0	6.0	14.0	17.4 1865
Franklin,	4.5	4.0	7.9	10.6	16.4 10 A. M.	13.1	10.6	8.7	7.2	------	------
Clarion,	2.9	3.0	6.0	12.0 5 P. M.	10.0	6.6	5.8	5.3	4.8	10.0	15.2 1904
Parker,	4.8	4.7	6.3	8.5	17.5	11.6	7.8	7.0	6.5	20.0	28.0 1865
Kittanning,	------	------	------	18.9	24.8 9 P. M.	18.7	15.4	12.8	------	------	------
Freeport,	4.3	4.8	7.0	20.3	28.4	22.0	17.6	13.8	12.0	20.0	32.7 1891
Johnstown,	2.0	2.6	5.0	13.4 6 P. M.	8.0	5.1	3.9	3.8	3.6	7.0	21.0 1889
Blacklick,	3.0	3.9	5.3	11.6 5 P.M.	7.5	5.5	4.5	4.3	4.1	------	------
Saltsburg,	Froz.	9.5	9.9	11.0 6 P. M.	9.5	5.0	3.5	2.8	2.2	6.0	22.1 1859
Avonmore,	------	------	------	22.6 5 P.M.	21.4	11.8	8.8	7.8	------	------	------
Aspinwall,	18.6	18.8	23.3	35.9	40.0 Noon.	34.4	29.9	27.2	25.6	------	42.6 1907
Herrs Island,	3.9	5.6	8.5	19.9	32.6 1 P. M.	27.5	19.6	14.8	12.7	22.0	36.4 1907
Monongahela.											
Fairmount,	15.8	17.0	18.5	19.8	----------	19.8	17.0	16.6	17.7	25.0	37.0 1888
Rowelsburg,	Froz.	------	------	8.0	----------	5.5	4.5	4.0	3.8	14.0	22.0 1888
Greensboro,	8.5	10.4	13.6	15.8	22.0 1 A. M.	14.7	11.4	10.0	10.4	18.0	39.0 1888
Lock No. 4,	10.5	11.5	16.1	20.3	28.5	21.5	15.8	13.7	12.5	28.0	42.0 1888
East Pittsburg,	2.3	3.0	3.6	7.5 Noon.	Back W. 10.7 1 P. M.	5.3	2.4	2.0	1.9	------	------
Confluence,	Froz.	Froz.	3.8	-------- 4 P. M.	8.2	5.0	3.5	3.0	2.5	10.0	18.0 1888
West Newton,	Froz.	4.5	8.0	18.0 11P.M.	16.5	7.8	5.8	4.1	4.0	23.0	26.3 1907
Pittsburg,	3.4	5.0	7.7	17.8	30.7 1 P. M.	26.0	17.5	13.1	11.0	22.0	35.8 1907
Ohio.											
Davis Island,	5.6	7.5	10.3	16.6	29.1 1 P. M.	25.8	17.3	13.5	12.1	25.0	33.7 1907
Dam No. 2,	4.7	6.7	9.1	15.8	29.4	27.4	18.1	13.0	11.0	------	------
Ellwood Junc.,	Froz.	Froz.	4.3	9.6	10.6	9.0	8.1	4.6	3.4	14.0	22.8 1904
Beaver Dam,	7.0	8.7	13.4	23.5	41.3 8 P. M.	39.2	26.0	20.8	17.1	27.0	43.0 1902
Wheeling,	6.9	7.9	10.8	19.8	34.0	42.8 10P.M.	39.2	29.3	20.9	36.0	53.1 1884

SUSQUEHANNA BASIN.

Station.	Date.								Flood stage.	Previous maximum.
	12	13	14	15	16	17	18	19		
W. Branch.										
Clearfield,	Froz.	Froz.	Froz.	8.5 P. M.	7.3	4.2	3.0	2.5	8.0	17.0 1889
Renovo,	Froz.	Froz.	Froz.	3.6	13.4 A. M.	9.4	6.8	5.5	35.0	27.3 1889
Williamsport,	2.2	2.1	2.1	2.6	17.0 A. M.	13.2	9.3	7.4	20.0	33.5 1889
N. Branch.										
Binghamton,	-------	-------	-------	4.0	14.0 10A.M.	-------	9.1	------	16.0	19.7 1902
Towanda,	-------	-------	-------	-------	15.8 4 P. M.	12.8	9.8	6.3	16.0	29.0 1869
Wilkes-Barre,	6.0	5.9	5.9	7.1	19.6	21.8 8 A. M.	17.7	14.0	17.0	33.1 1865
Danville,	-------	-------	-------	10.6	15.9	17.2 5 P. M.	14.4	11.7	------	------
Susquehanna.										
Selins Grove,	-------	-------	-------	3.5	13.0 P. M.	12.2	10.0	7.6	17.0	20.0 1889
Harrisburg,	Froz.	Froz.	Froz.	3.7	15.2 10P.M.	14.4	12.3	9.6	17.0	26.1 1889
Juniata.										
Huntingdon,	-------	-------	-------	10.2 P. M.	8.7	5.5	5.2	4.8	24.0	25.0 1889
Hahns Bridge,	-------	-------	-------	6.8	12.1 8 A. M.	8.2	6.6	5.0	------	------
Newport,	Froz.	Froz.	5.3	8.5	14.2 8 A. M.	11.7	7.7	6.4	------	------

DELAWARE BASIN.

Station.	Date.								Flood stage.	Previous maximum.
	12	13	14	15	16	17	18	19		
Delaware.										
Port Jervis,	1.0	1.8	3.1	3.7	11.8	6.8	4.6	3.7	14.0	23.5 1904
Phillipsburg,	Froz.	2.2	2.2	4.8	14.2	12.9	8.5	6.8	26.0	------
Trenton,	3.5	3.5	3.5	7.0	10.0	10.0	6.2	------	18.0	------
Lambertville,	-------	-------	-------	-------	-------	-------	------	------	------	------
Riegelsville,	-------	-------	-------	-------	-------	-------	------	------	------	------
Lehigh.										
Mauch Chunk,	Froz.	Froz.	Froz.	Froz.	8.5	6.4	5.4	------	15.0	------
Schuylkill.										
Pottsville,	-------	-------	-------	-------	-------	-------	------	------	------	------
Reading,	0.6	0.6	0.8	4.5	6.3	2.9	1.9	------	12.0	22.0 1850

Note—The maximum stage reached was not recorded at the stations in the Delaware basin.

It is seen that the streams were low on the 12th and 13th, with only a slight rise on the latter day, but by the morning of the 14th the smaller rivers had risen considerably; more in the west than in the Susquehanna and Delaware Basins. On the morning of the 15th the smaller streams were approaching their maximum stages, which as a rule were reached that night, while it was not until the 16th that the larger streams reached their crests. At no station was the crest above the previously recorded maximum, and in few instances was it dangerously approached, the three rivers at Pittsburg rising nearest to previous maximum, reached 30.7 feet at 1 P. M. on the 16th, 5.1 feet below the record flood of March 15, 1907. This city had been warned to prepare for a stage of 31 feet and the losses are said to have been considerably lessened by this timely forecast. The lower streets bordering the rivers in Pittsburg and Allegheny were submerged and the cellars flooded throughout much of the business section of both cities. Above their junction, neither the Allegheny nor Monongahela rivers were at damaging heights. In the Susquehanna and Delaware Basins the large rivers did not exceed the danger line, and the losses along the main valleys were small.

The highest water from the upper Allegheny river did not reach Pittsburg until after the maximum stage had passed that point, the Monongahela river flood meeting the high water from the lower Allegheny river causing probably the maximum stage. In like manner the high water in the lower Susquehanna river was mostly from the West Branch, as the crest did not reach Danville on the North Branch, 12 miles above the junction of the North and West Branches, until 5 P. M. on the 17th, 17 hours after the crest from the West Branch and the main stream had reached Harrisburg, notwithstanding the fact that a precipitation of 1.2 inches was recorded at Wilkes-Barre on the 14th, while the rain came on the 15th, all over the West Branch.

The Lehigh river flooded a portion of the plant of the Bethlehem Steel Company at South Bethlehem, and caused the shutting down of industries in the lower portion of Allentown. Monocacy creek, a tributary of the Lehigh river at Bethlehem, rose high and flooded houses in its valley; Jordan creek and Little Lehigh river flooded the tracks of the Lehigh Valley, Jersey Central and Philadelphia and Reading railroads.

A portion of the town of North Pine Grove was submerged by the formation of an ice gorge in Swatara creek, formed on February 15th; Quittapahilla creek and the Hazle Dyke, at Lebanon, rose on the afternoon of the 15th to nearly the maximum of 1902, forming a large lake on the south and west borders of the city, submerging street railway tracks and houses and industrial plants. Spring creek, at Harrisburg, washed out a stone arch bridge, stopped traffic on two street car lines, and caused about $500.00 worth of damage to city streets and Park roads. Paxton creek, at Harrisburg, was at its highest on the evening of the 15th, when it flooded meadows and houses in its valley. Small streams tributary to the North Branch at Berwick and West Berwick inundated several houses and the American Car and Foundry Works, while trolley traffic between Berwick and Bloomsburg was cut off and the lower end of the Bloomsburg Division of the Delaware, Lackawanna and Western Railroad was submerged. Catawissa creek, joining the North Branch from the south at Catawissa, rose rapidly at Mainville, damaging the county bridge.

Conococheague creek had one of the worst floods in years, submerging the electric light plant at Chambersburg, and carrying away several bridges. Stony creek and the Conemaugh river flooded cellars and blocked street car traffic at Johnstown. The Shenango river rose at Sharon to within 2 feet of its maximum flood height, submerging residence and business districts.

Table No. 31 shows the maximum stage and discharge reached at gaging stations of the Commission during this period, together with the previous maximum discharge recorded.

TABLE NO. 31.

Estimated Maximum, Greatest Height and Discharge, February Freshet.

Station.	Date.	Gage Height. Feet.	Discharge. Second-feet.	Previous maximum discharge. Second feet.	Remarks.
Harrisburg,	Feb. 17,	15.2	269,900	700,000	
Williamsport,	Feb. 17,	17.0	108,000	164,100	
Wilkes-Barre,	Feb. 17,	21.8	115,000	217,700	
Danville,	Feb. 17,	17.2	124,400	304,800	
Newport,	Feb. 16,	14.2	43,600	113,600	
Huntingdon,	Feb. 17,	10.2	----------	----------	New Station.
Hawns Bridge,	Feb. 16,	12.1	17,700	----------	New Station.
Avonmore,	Feb. 15,	22.6	47,000	----------	New Station.
Aspinwall,	Feb. 15,	40.0	280,000	----------	New Station.
Confluence,	Feb. 15,	15.0	17,900	----------	New Station.
Kittanning,	Feb. 15,	24.8	183,000	232,000	
Turtle Creek,	Feb. 15,	7.5	3,300	9,375	
Blacklick,	Feb. 15,	11.6	12,100	18,000	

FRESHETS OF MARCH.

The rivers rose in March to several maximums, though none but the Kiskiminetas and Juniata were unusually high and only a few reached the heights of the February freshet. No such simultaneous and general rise took place as in February, but two or more crests were reached. The freshet of February was followed by a period of cold, considerable snow fell and the streams quite generally dropped to points approximately as low as had preceded this rise.

Snow accumulated until the depth approximated that on the ground at the time of the February thaw, and rain falling upon and melting it caused the several rises, as in the previous month. The streams of the Delaware Basin were little affected during March, while the streams of the Susquehanna Basin were the most affected, in some cases reaching higher stages than in February. Table No. 32 shows the stages at the various observation stations in the Ohio and Susquehanna Basins during this period, those of the Delaware Basin not being presented owing to the unimportance of the freshets in this basin. The maximum stage reached is shown by asterisks.

TABLE NO 32.

OHIO BASIN.

March. Date.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Flood stage.	Previous maximum.
Station.																							
Allegheny.																							
Warren,	1.6	3.0	*5.0	4.5	4.5	4.2	5.2	5.0	4.7	4.2	3.8	4.6	6.0	8.0	8.5	*10.0	9.2	8.3	8.1	7.2	6.3	14.0	17.4 1865
Franklin,	2.4	4.6	*8.5	7.2	6.9	6.6	8.5	8.4	7.7	6.6	5.6	5.7	7.6	8.9	9.6	*11.1	10.6	9.1	10.9	9.6	7.8	------	------
Clarion,	4.5	--------	*8.5	6.2	5.1	4.6	6.0	5.6	5.0	4.7	4.3	8.7	5.5	8.8	8.5	------	------	8.6	11.5 noon.	9.0	------	10.0	15.2 1904
Parker,	2.3	5.5	*10.0	8.2	7.3	7.1	9.4	8.5	8.0	6.9	5.9	5.9	7.1	8.7	10.5	*11.8	11.0	10.1	12.8 4 P.M.	11.4	9.4	20.0	28.0 1865
Kittanning,	------	--------	--------	------	------	------	--------	--------	------	------	9.8	10.4	12.9	14.5	15.4	*16.8	16.5	16.9	19.8 6 P.M.	17.6	16.9	------	------
Freeport,	5.6	10.0	*17.7	15.0	12.7	13.0	19.8	*20.9	15.2	13.3	12.0	11.1	11.9	14.2	16.5	*18.0	17.8	15.2	*28.7 8 P.M.	23.0	15.3	20.0	32.7 1891
Johnstown,	2.5	4.5	*6.2	4.8	5.0	6.6	9.8	6.8	8.0	5.5	5.0	6.0	6.5	7.5	6.5	7.0	5.5	4.8	*16.7	8.0	5.5	7.0	21.0 1889
Blacklick,	3.6	6.9	6.2	5.3	5.0	8.4	9.1	6.5	6.4	5.5	5.0	5.2	5.4	6.1	5.8	6.1	5.2	6.2	*11.3 8 A.M.	6.6	5.3	------	------
Saltsburg,	1.0	4.5	6.2	4.5	4.2	4.5	8.8	7.0	6.2	5.0	4.2	4.3	4.8	5.2	5.2	6.0	4.7	3.5	*18.0 2 P.M.	9.2	5.5	6.0	22.1 1859
Avonmore,	------	--------	--------	------	------	------	--------	--------	------	------	10.0	10.3	10.6	10.9	11.0	13.2	9.9	10.7	*30.8 3 P.M.	18.0	12.0	------	------
Aspinwall,	23.5	29.8	28.3	28.1	26.3	26.7	*31.1	28.2	26.2	27.2	25.6	24.7	25.4	26.7	28.6	30.2	30.0	28.0	*37.8 12P.M.	36.9	29.3	------	42.6 1907
Herrs Island,	5.0	11.6	21.8 10A.M.	18.4	14.1	13.5	*22.4 2 A.M.	21.7	17.7	18.7	14.7	12.4	12.3	14.0	16.4	17.1	17.8	15.5	22.6	*29.7	19.1	22.0	36.4
Monongahela																							
Fairmount,	------	*22.3	20.7	18.0	17.0	16.9	18.6	--------	*22.7	20.5	18.4	17.2	16.6	10.2	------	15.9	15.9	15.7	18.2	*19.5	17.9	25.0	37.0 1888
Rowelsburg,	------	7.0	6.4	5.2	4.6	4.8	7.8	--------	7.0	6.8	5.6	4.2	3.5	3.2	------	2.8	2.7	2.6	5.8	6.8	4.8	14.0	22.0
Greensboro,	8.7	*18.5 6 A.M.	16.8	13.0	11.0	10.6	14.0	14.0	17.1	15.6	12.8	10.9	10.0	9.2	9.2	9.2	9.3	9.0	12.8	*15.5 2 A.M.	12.3	18.0	39.0 1888 1888 1907

*Indicates maximum stage.

Lock No. 4,	10.2	16.1	*24.0	18.5	14.8	13.2	20.0	19.5	19.3	22.8	17.9	14.7	12.9	11.9	11.7	11.2	11.0	10.9	17.5	23.0	17.0	22.0	42.0 1888
E. Pittsburg,	2.4 *7.5	4.8	4.2	2.3	2.1	5.0 3.8	3.5	3.2	3.3	3.2	2.4	2.2	2.1	2.3	2.9	2.4	2.3	2.4 5.8	*7.4 5.9	5.0	2.5	------	------
Confluence,	1.6	3.6	6.4	4.6	4.2	5.2	8.8	7.0	*8.9	6.0	4.5	4.3	4.4	4.8	4.3	4.4	3.6	2.7	*9.0	6.5	4.3	10.0	18.0 1888
W. Newton,	2.0	5.2	*10.4	7.5	5.9	6.1	13.5 7 A. M.	11.5	10.6	9.7	6.9	5.8	5.4	5.7	5.9	5.9	5.5	4.4	*15.1	12.6	7.1	23.0	26.3 1907
Pittsburg, -	4.2	10.6	*20.5 10 A.M.	17.5	12.8	11.7	*20.9 1 A.M.	20.5	16.2	18.2	14.0	11.7	11.2	12.0	14.1	14.8	15.5	13.0	20.4	*27.3	17.8	22.0	35.8 1907
Ohio.																							
Davis Island,	6.8	11.9	20.0 1 P.M.	17.2	13.4	12.8	*20.1 2 A.M.	19.6	16.3	17.7	14.2	12.4	12.1	12.8	14.4	14.8	15.4	13.6	19.6	*26.2	17.8	25.0	33.7 1907
Dam No. 2, -	5.9	10.4 4 P.M.	20.2	17.8	12.9	11.8	17.8	20.5	16.6	18.1	14.0	11.4	11.0	11.8	13.9	14.4	15.3	13.1	19.5	*27.3	18.7	------	------
Ellwood Jc.,	2.3	*13.2	11.0	8.6	6.6	7.6	--------	10.7	0.5	0.2	------	3.8	2.8	2.9	2.8	3.1	3.0	2.9	8.0	9.0	6.2	14.0	22.8 1904
Beaver Dam,	8.7	19.0	30.1	28.5	*32.0	19.1	27.3	31.0 3 A.M.	26.5	26.7	22.3	18.5	17.4	18.2	20.5	21.2	22.5	20.0	26.6	*38.1	30.0	27.0	43.0 1902
Wheeling, --	9.2	14.9	26.1	*32.0	28.0	21.9	24.3	*31.6	31.6	28.7	27.2	------	18.5	17.7	19.2	21.2	22.7	22.3	26.7	*39.6 8 P. M.	38.4	36.0	53.1 1884

*Indicates maximum stage.

SUSQUEHANNA BASIN.

Date—	11	12	13	14	15	16	17	18	19	20	21	22	23	Flood stage.	Previous maximum.
Station.															
W. Branch.															
Clearfield,	3.0	3.8	4.5	5.7	5.0	6.0	4.5	3.5	*7.8	6.7	4.0	3.0	2.8	8.0	17.0 1889
Renovo,	5.3	6.2	7.8	10.3	10.5	13.3	10.5	8.2	10.6	*13.4	9.1	7.0	6.5	16.0	27.3 1889
Williamsport,	6.4	6.7	8.5	11.2	13.4	15.8	15.0	11.4	*17.6	17.4	13.1	9.9	8.5	20.0	33.5 1889
N. Branch.															
Binghampton,	2.9	3.2	4.8	9.6	11.5	*17.5	10.4	7.4	6.6	6.0	5.0	4.7	4.9	16.0	19.7 1902
Towanda,	2.7	3.5	6.6	11.8	13.0	*13.8	11.8	8.3	7.5	7.8	6.3	5.0	4.8	16.0	29.0 1869
Wilkes-Barre,	6.3	7.0	10.4	17.3	20.6	*22.0	20.9	16.9	14.9	16.1	13.0	11.0	10.3	17.0	33.1 1865
Danville,	5.7	6.6	7.4	12.4	16.1	*16.9	15.5	14.7	13.5	14.1	12.2	10.7	9.8	--------	--------
Susquehanna.															
Selins Grove,	4.3	4.8	5.4	8.1	11.3	12.4	9.5	*13.1	10.5	12.4	10.5	7.9	6.3	17.0	20.0 1889
Harrisburg,	6.9	7.1	7.7	9.4	12.7	*15.5	14.8	13.0	12.7	*16.0	14.1	10.4	8.6	17.0	26.1 1889
Juniata.															
Huntingdon,	6.3	7.9	8.3	9.2	8.4	9.2	7.5	6.7	*13.6	9.7	7.3	6.5	6.1	24.0	25.0 1889
Newport,	9.9	10.7	11.7	12.8	12.2	12.3	11.2	9.6	19.3	*20.7	13.9	9.7	8.3	--------	--------
Hawns Bridge,	8.3	8.8	9.3	9.3	9.3	8.8	8.0	8.0	*14.9	12.6	8.8	7.3	6.7	--------	--------

*Indicates maximum stage.

TABLE NO. 33.

Estimated Maximum Discharge, March, 1908, and Previous Maximums.

Station.	Date.	Gage height in feet.	Discharge. Second-feet.	Previous maximum discharge. Second-feet.	Remarks.
Harrisburg,	March 20,	15.9	288,800	700,000	
Williamsport,	March 20,	17.4	100,800	164,100	
Wilkes-Barre,	March 16,	22.0	116,000	217,700	
Danville,	March 16,	16.9	120,000	304,800	
Newport,	March 20,	20.75	84,000	113,600	
Huntingdon,	March 19,	13.8	38,600	----------	New Station.
Hawns Bridge,	March 19,	14.9	26,100	----------	New Station.
Avonmore,	March 19,	30.8	75,000	----------	New Station.
Aspinwall,	March 19,	37.83	245,000	----------	New Station.
Confluence,	March 19,	11.0	11,900	----------	
Kittanning,	March 19,	19.8	141,500	232,000	
Turtle Creek,	March 19,	7.4	3,500	9,375	
Blacklick,	March 19,	11.1	13.100	18,000	

The most general March rise extended from the 18th to 21st, others occurring on some streams on the 3rd, 7th, and 16th. The flood beginning on the 18th much resembled that of February in its causes and effects. Preceding this freshet, on the 18th and 19th, the rain was generally heavier than in February and was concentrated in the two days, the average precipitation for the Delaware Basin being 1.36 inches, for the Susquehanna 1.63 inches, and for the Ohio 1.83 inches. The greatest precipitation was at Johnstown, 3.55 inches, but the rise in temperature was not marked, the freshet having been preceded for several days by temperatures rising quite generally above freezing.

TABLE NO 34.

Average Precipitation Preceding Freshet of March 18th to 20th, by Drainage Basins.

Basin.	March 18.	March 19.	Total.
Delaware Basin,	0.80	0.56	1.36
Susquehanna Basin,	0.80	0.83	1.63
Ohio Basin,	0.81	1.03	1.83
Potomac Basin,	0.81	0.80	1.61
Erie Basin,	0.06	0.03	0.09

In the west the Allegheny river at Aspinwall reached a maximum stage of 37.8 at midnight of the 19th, against a stage of 40 feet on February 16th, at Kittanning the river rose to only 19.8 on March

19th, against 24.8 on February 16th, but the Kiskiminetas river at Avonmore rose to 30.8 on March 19th against 22.6 on February 15th. The height reached by the Kiskiminetas river was due to the intense precipitation which fell upon the upper portion of its watershed. The two streams most affected during this freshet were the Kiskiminetas and Juniata rivers, whose headwaters abut one another on opposite sides of the Alleghenies. The Monongahela river at Lock No. 4 was 5.5 feet lower than in February, while the Youghiogheny river at West Newton was 5.4 feet lower. The Monongahela river at Pittsburg was 27.3 on March 20th, agaisnt 30.7 on February 16th, and the Ohio river at Wheeling, 39.6 against 42.8 in February.

In the Susquehanna Basin, the West Branch at Williamsport was 17.6 on March 19th, against 17.0 on February 16th, and the North Branch at Danville 16.9 on March 16th, against 17.2 on February 17th; thus the West Branch was a little lower and the North Branch a little higher in the February freshet. The Juniata river reached 20.7 feet on March 20th, against 14.2 during February, and the Susquehanna river at Harrisburg rose to 16.0 on the 20th, against 15.2 on February 16th. Thus it appears that the March high water generally exceeded that of February in the Susquehanna Basin, and was several feet lower than the February flood on the western streams. The North Branch flood this time preceded that from the West Branch, while it followed the flood in the West Branch in February, and in neither case is this phenomenon explained by the distribution of the precipitation. The North Branch crest, coming down and meeting a small rise in the West Branch, caused a stage of 15.3 at Harrisburg on March 16th, while the West Branch flood coming on the 19th, caused the Susquehanna river at Harrisburg to rise to 16 feet on the 20th. Had the maximums on the two branches met at their junction, a higher stage at Harrisburg would have resulted, particularly if this crest had met the high water from the Juniata.

The freshets of March 3rd and 7th followed small rains and were of minor importance, at no point reaching stages equal to those of February 16th and March 18th to 21st.

ADDITIONAL FLOOD DATA AT PITTSBURG.

The city of Pittsburg has recognized the gravity of the flood problem at that point, and a flood commission consisting of members of the Chamber of Commerce was appointed to study the problem and suggest methods of relief. Members of the Committee visited various European countries during the year, looking into foreign methods of flood amelioration and protection, while studies are in progress of the causes, effects and possible methods of relief of the freshet conditions at Pittsburg. In this investigation the question has arisen as to whether it is advisable to attempt measures to reduce the height of the floods, or to try to protect the city from floods even higher than that of March, 1907. The former course would benefit other communities than Pittsburg, and should involve co-operation among the many communities benefitted, while the latter would afford purely local relief.

Through the kindness of Henry Pennywitt, Local Forecaster, United States Weather Bureau, Pittsburg, we are able to present herewith a list of the flood heights on the Ohio river at Pittsburg, compiled from "Historical Gleanings," by Judge John E. Parke, records of the U. S. Engineer Corps, U. S. Signal Corps, and U. S. Weather Bureau. This list supplements that published in the report of the Commission for 1907.

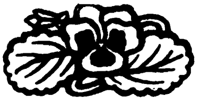
TABLE NO. 35.

Record of Floods in the Ohio River at Pittsburg and Wheeling.

Flood Stage at Pittsburg, 22 feet, and at Wheeling, 36 feet.

Year.	Day of Month.	Stage at Pittsburg.	Stage at Wheeling.	Year.	Day of Month.	Stage at Pittsburg.	Stage at Wheeling.
1806	April 10,	33 9	--------	1886	April 7,	22 8	32 0
1810	Nov. 9,	32 0	48 6	1887	February 12,	22 0	33 8
1813	January,	29 0	--------	1887	February 27,	22 0	30 3
1816	February,	33 0	--------	1888	July 11,	22 0	27 1
1832	February 10,	35 0	48 1	1888	August 22,	26 0	32 2
1840	February 1,	26 8	--------	1889	June 1,	24 0	28 9
1846	March 15,	25 0	--------	1890	March 23,	24 3	33 0
1847	February 2,	26 9	--------	1890	May 24,	22 0	27 5
1847	December 12,	24 0	--------	1891	January 8,	23 2	33 7
1848	December 22,	23 0	--------	1891	February 18,	31 3	44 6
1851	Sept. 20,	30 9	--------	1892	January 15,	23 0	29 1
1852	April 6,	25 0	--------	1893	February 8,	24 0	34 2
1852	April 19,	31 9	48 0	1893	February 11,	22 0	33 4
1858	May 27,	26 0	--------	1994	May 22,	23 2	29 9
1859	April 28,	22 0	--------	1895	January 8,	25 8	36 0
1860	April 12,	29 7	43 0	1896	July 26,	28 0	27 6
1860	November 4,	22 0	--------	1897	February 24,	29 5	38 8
1861	Sept. 29,	31 0	44 2	1898	March 24,	28 9	44 6
1862	January 21,	30 0	--------	1899	March 6,	22 0	28 2
1862	April 22,	27 9	37 0	1900	Nov. 27,	27 7	34 7
1865	March 4,	24 5	--------	1901	April 7,	22 1	30 0
1865	March 18,	31 4	41 0	1901	April 21,	27 5	41 8
1867	February 15,	22 0	--------	1901	December 16,	25 8	34 0
1867	March 13,	23 5	--------	1902	March 1,	32 4	43 3
1868	March 18,	22 0	--------	1903	February 5,	24 0	34 6
1873	December 14,	25 7	38 8	1903	March 1,	28 9	40 2
1874	January 8,	22 2	38 8	1904	January 23,	30 0	44 2
1876	Sept. 19,	25 0	--------	1904	March 4,	26 9	39 2
1877	January 17,	24 6	--------	1904	March 8,	23 2	36 3
1878	December 11,	24 5	34 9	1905	March 22,	29 0	42 9
1881	February 11,	23 2	38 8	1905	December 4,	23 5	31 6
1881	June 10,	27 1	40 9	1907	January 20,	23 3	37 0
1883	February 5,	24 8	39 7	1907	March 15,	35 5	50 1
1883	February 8,	28 0	35 6	1907	March 20,	22 4	31 8
1884	February 6,	33 3	52 6	1908	February 16,	30 7	42 8
1885	January 17,	23 0	32 9	1908	March 20,	27 3	39 6

APPENDIX A.



REPORT OF THE ENGINEER

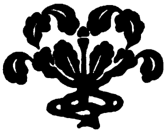
TO THE

WATER SUPPLY COMMISSION OF PENNSYLVANIA,

UPON THE CAUSES OF AND METHODS OF RELIEF

FROM

FLOODS IN TURTLE CREEK, WESTMORELAND AND ALLEGHENY COUNTIES.



In reply to requests from the Business Men's Association of Turtle Creek Valley, Allegheny and Westmoreland Counties, an examination was made by the Commission of the flood conditions in the valley of this stream, as it was considered that conditions along this stream were typical of those along many larger streams throughout the Commonwealth. The study resulted in a report to the Commission by its Engineer, embodying the underlying causes of the floods and certain recommendations for their amelioration. This report was subsequently transmitted to the Turtle Creek Business Men's Association, printed and distributed by them and certain of its recommendations are being carried out, while it is the intention to incorporate others in a bill to be presented to the Legislature of 1909 asking for an appropriation for carrying them out. The Commission considers that such conditions as those effecting this stream and the methods by which they may be relieved should be generally known, and with the hope that the suggestions therein contained may perhaps be applied to other streams of the State, the Engineer's report is printed below.

REPORT OF THE ENGINEER

TO THE

WATER SUPPLY COMMISSION OF PENNSYLVANIA,

UPON THE

CAUSES OF AND METHODS OF RELIEF FROM FLOODS IN TURTLE CREEK, WESTMORELAND COUNTY.

Harrisburg, Penna., Jan. 30, 1908.

Water Supply Commission of Pennsylvania:

Gentlemen: I have the honor to submit herewith a report upon flood conditions in Turtle creek, with suggestions as to methods of amelioration, based upon a study of this stream and the available data concerning it.

1. Three kinds of floods occur in Turtle creek valley, namely: local floods in the main creek, floods in small tributaries, and back water floods from the Monongahela river.

2. Considerable actual damage has been done by these floods to property in the valley, the operation of sewerage systems has been impaired and a noticeable depreciation in the value of real estate has been caused. Practically all the damage has been done below the junction of Brush creek and Turtle creek, six and one-half miles above the mouth of Turtle creek in the Monongahela river.

3. Local creek floods are caused by unusually rapid run-off from a hilly, deforested drainage basin and are aggravated by the fact that the creek bed has been raised through the deposition of material washed down from above, while its channel has been contracted and distorted by obstructions.

4. The greatest flood in the creek, which extended up the stream beyond Turtle Creek borough, was caused by back water from a flood in the Monongahela river.

5. Local creek floods may be controlled by improving the channel and by the storage in reservoirs at points above, of the surplus water that the improved channel is unable to carry. Floods in some of

the tributaries may be controlled by like means. Back water floods might be prevented, theoretically, by the construction of tide gates, operating in conjunction with storage reservoirs; but such gates are not recommended for reasons which appear below, and these floods can probably be handled only through controlling floods in the Monongahela and Youghiogheny rivers.

DESCRIPTION OF CREEK.

Turtle creek rises in eastern Westmoreland county and is joined at Trafford City near the western Allegheny county line by Brush creek, which rises near Greensburg, Westmoreland county. The two branches at Trafford City are of nearly equal size, draining a total of 113 square miles, approximately three-quarters of the entire basin of the creek. The stream drains an area of 146 square miles, fan shaped in form, diverging rapidly above Trafford City, 6½ miles above the mouth. Below this point only one tributary of considerable size is received; namely, Thompsons run, which comes in from the north at Turtle Creek borough, 2 miles above the mouth, and drains 16 square miles.

TABLE NO. 36.

Table of Drainage Areas of Turtle Creek and Tributaries.

Stream.	Drainage area in sq. miles.	Per cent. of total.
Brush creek,	57	39
Turtle creek above mouth of Brush creek,	56	39
Thompsons run,	16	11
Direct drainage into Turtle creek exclusive of above,	17	11
Turtle creek, total,	146	100

Extensive deforestation has taken place on the catchment areas of both Turtle creek and Brush creek and a high rate of run-off may be expected. The maximum flood discharge from these two creeks may be expected to reach Trafford City, nearly simultaneously, and their combined flow must then descend the main creek. It is this combined discharge that produces the high water at points below, so that if the flow of one of these branches could be retarded in order that its maximum would come after that on the other, the flood height below would be materialy reduced. The following table shows the extensive depletion of the timber on these watersheds, there being now but 6.7 per cent. of the entire drainage basin forest covered, while on Brush creek but 3.5 per cent. remains in forest.

TABLE NO. 37.

Table Showing Forest Cover on Turtle Creek and Tributaries.

Stream.	Total drainage area in sq. miles.	Area forest covered in sq. miles.	Per cent. of total area that is in forest.
Turtle creek,	146	10	6.7
Brush creek,	57	2	3.5
Thompsons run,	16	1.6	10
Turtle creek exclusive of Brush creek and Thompsons run,	73	7.3	10

RUN-OFF.

Previous to this investigation there had been no discharge measurements made on this creek and an estimate of the maximum run-off to be provided for could be arrived at only by a comparison with other watersheds of similar size and condition, and by a computation of the discharge during past floods based upon the flood slope and cross section. Since taking up this study, however, two gaging stations have been established, one on Turtle creek at East Pittsburg, on November 1st, 1907, and one on Brush creek at Irwin, on January 10th, 1908. Three current meter measurements have been made at East Pittsburg, on November 7th, 1907, January 10th, 1908, and February 15th, 1908, and two at Irwin, on January 10th, 1908, and February 15th, 1908, Table No. 38 shows the results of these measurements.

TABLE NO. 38.

Discharge Measurements on Turtle and Brush Creeks.

Date of Measurement.	Station.	Gage height ft.	Dis. sec.-ft.	Drain. area above sta.	Run-off sec.-ft. Pr. sq. mile.
Nov. 7, 1907,	Turtle creek at East Pittsburg,	1.85	477.3	145	3.3
Jan. 10, 1908,	Turtle creek at East Pittsburg,	1.35	58.1	145	0.4
Feb. 15, 1908,	Turtle creek at East Pittsburg,	6.85	2,931	145	20.2
Jan. 10, 1908,	Brush creek at Irwin,	----------	28.7	38	0.75
Feb. 15, 1908,	Brush creek at Irwin,	----------	696	38	18.3

A computation of the maximum rate of discharge of Turtle creek at the Cable avenue bridge, East Pittsburg, during the flood of March, 1904, the largest local creek flood recorded, using the determined cross section and slope, and the information gained regarding the friction coefficient through the gagings, gives a total discharge of 9375 second-feet, or 64 second-feet per square mile of drainage area.

A study of Neshaminy creek, near Philadelphia, shows a maximum run-off of 136 second-feet per square mile, in the twenty-three years of the record. The general conditions on this watershed are similar to those on that of Turtle creek, but it should be noted that the basin of the Neshaminy is subject to 5 inches more average annual rainfall than that of Turtle creek and that individual rainstorms of which we have record have reached greater intensity on the catchment area of the eastern stream. Thus the rainfall which caused the above high run-off on the Neshaminy watershed was 5.25 inches in 20 hours, while the rainfall which caused the greatest local flood in Turtle creek, that of March, 1904, was only 1.75 inches in somewhat less than 24 hours. We may fairly expect a higher percentage of the rainfall to run off immediately on Turtle creek drainage basin, for from a rainfall of only 1.75 inches in 24 hours there was a run-off of 64 second-feet per square mile of drainage area, against a run-off on the Neshaminy of 136 second-feet per square mile with 5.25 inches of rainfall in 20 hours; apparently one-third as much rainfall gave, on Turtle creek, nearly half as high a rate of run-off.

POPULATION.

The upper watershed of this stream is highly developed agriculturally, while the lower portions of the valleys of the main stream, Brush creek and Thompsons run, are thickly settled, containing approximately 43,000 inhabitants, and are congested by railroads and industrial establishments. The entire watershed has a population of approximately 65,000, giving 446 inhabitants per square mile. Tables Nos. 39 and 40 show the boroughs and larger towns in the valleys of Turtle creek and Brush creek with the population of the boroughs in 1900 and estimated present population.

TABLE NO. 39.

Populations of Boroughs in Turtle Creek Valley.

Name of Borough.	Population in 1900.	Estimated present population.
Jeannette,	5,865	9,000
Irwin,	2,452	3,500
Wilmerding,	4,179	5,500
Wall,	----------	500
Turtle Creek,	3,262	4,000
East Pittsburg,	2,883	4,000
North Braddock,	6,535	7,000
Pitcairn,	2,601	3,000
Penn,	763	800
Manor,	684	800
North Irwin,	403	450
Trafford,	----------	2,100
Total,	29,627	40,650

TABLE NO. 40.

Estimated Present Population of Unincorporated Towns in Turtle Creek Valley.

Name.	Estimated present population.
Export,	600
Westmoreland city,	500
Larimer,	300
Newlandsburg and Murrysville,	300
Total,	1,700

ECONOMIC CONDITIONS IN THE VALLEY.

The valleys of Turtle creek and Brush creek are densely populated, there being a succession of boroughs and towns which extend almost continuously from North Braddock at the mouth of the creek to Jeanette, near the headwaters of Brush creek, a distance of about 20 miles. From Trafford City to its mouth, 6½ miles, the creek valley is an important industrial region. The main line of the Pennsylvania Railroad follows Brush creek from its source to its junction with Turtle creek and thence down that stream to East Pittsburg about three-quarters of a mile above the mouth. At most points it is a four track line, following the creek bank closely, while from Trafford City to Wilmerding, 2½ miles, is an extensive freight classification yard, with round houses and shops. The Turtle Creek branch of the Pennsylvania Railroad follows, by single track, the valley of that creek from its junction with Brush creek to Export near its source. The Bessemer and Lake Erie Railroad follows the main creek from its mouth to Thompsons run, and up that stream to its source, being double track or more the entire distance, while the Westinghouse Interworks Railroad follows the north bank of the creek between East Pittsburg and Trafford City. The Baltimore and Ohio, and Pittsburg and Lake Erie Railroads cross the creek at its mouth. The Cleveland Gas Coal Co. Railroad follows Thompsons run for several miles above its mouth. Trolley tracks follow the stream, connecting the numerous towns in the lower portion of the valley.

At East Pittsburg, bordering the north shore of the creek are the extensive works of the Westinghouse Electric and Manufacturing Co. and the Westinghouse Machine Co., while at Wilmerding, on the south side of the creek, is the Westinghouse Air Brake Co.'s plant, and at Trafford City are located the Westinghouse Foundries. Other large plants are situated in this valley.

SLOPE OF CREEK.

The elevation at the sources of Turtle and Brush creeks is approximately 1,260 feet above sea level, and at their junction at Trafford City it is 756 feet, giving these streams a slope between these points at the rate of 25 feet per mile. For a few miles above Trafford City on both streams the grade is but 8 to 10 feet per mile, while immediately above their junction the valleys are broader and the grade less steep. Below Trafford City the slope is more uniform, being at the rate of 9 feet per mile. From the junction of Thompsons run, which enters at Turtle Creek borough about 2 miles above the mouth, the slope of the creek bed to the mouth is 18 feet or 9 feet per mile. The available fall in the creek, between these points, however, has been reduced to 10 feet, or 5 feet per mile, by the removal of the navigation dam on the Monongahela river, from a point above, to a point below the outlet of the creek. The effect of this dam on flood flow is discussed on a subsequent page.

Repeated floods have washed quantities of material from above, depositing it in the creek and raising its bed considerably. This deposit has resulted from the erosion from this extensively deforested watershed, and from the railroad and other embankments which are constantly under construction along the creek and its chief tributaries. It has probably been augmented by three low dams which cross the creek below the mouth of Thompsons run, and also by the reduction in velocity caused by the raising of the pool level at the mouth.

COURSE OF CREEK.

Above Trafford City both Turtle creek and Brush creek follow sinious courses, while below this point the channel is more direct, having been straightened somewhat in the course of the various construction works in the valley. There still remain certain sharp bends and turns, the straightening of which would result in less frictional loss and less eroding of banks during floods and in a slightly increased slope, permitting of added discharge. One such point is at the Pennsylvania Railroad crossing just below the Westinghouse Air Brake Co.'s plant at Wilmerding.

BRIDGES.

From its mouth to Wilmerding the creek is crossed by 14 bridges, of which eight carry railroads and six highways. Some of these structures obstruct the channel with their piers and abutments. The effect of these bridges on flood flow is discussed subsequently. From the mouth up these bridges are as follows:

TABLE NO. 41.

Bridges Over Turtle Creek, Mouth to Wilmerding.

Name.	Distance Above Mouth.	Location.
Pittsburg and Lake Erie R. R.,	At mouth.	
Lower Union bridge, Bessemer and Lake Erie R. R.	350 feet.	
Baltimore and Ohio R. R.,	650 feet.	
Port Perry highway,	1,850 feet.	
Middle Union bridge, Bessemer and Lake Erie R. R.	0.5 mile.	
Upper Union bridge, Bessemer and Lake Erie R. R.	3,600 feet.	
P. R. R. & P. Y. & C. bridge,	4,500 feet.	
P. R. R. stone arch bridge,	1.0 mile.	
Brinton Highway bridge,	5,500 feet.	
Cable avenue bridge, Westinghouse Elec. and Mach. Co.	1.5 miles.	East Pittsburg.
Highway bridge,	2.1 miles.	Turtle Creek borough.
P. R. R. bridge,	2.6 miles.	Wilmerding.
Highway bridge,	3.0 miles.	Wilmerding.
Highway bridge,	3.2 miles.	Wilmerding.

CHANNEL.

Throughout the section of the creek between Wilmerding and the mouth extensive alterations in the channel have been made. As stated above ,its course has been changed at some points while at others embankments, bridges and dams have encroached upon its cross section. At still other points the creek has been walled in between high masonry walls on both sides, while throughout this section its bed has been raised by sediment. Some of these alterations have been beneficial while others have resulted in an opposite effect on the flow of the creek. Table No. 42 includes the most prominent of such alterations.

TABLE NO. 42.

Prominent Alterations in and Encroachments upon the Channel of Turtle Creek Between Trafford City and the Mouth, Omitting Bridges.

Character.	Location.	Remarks.
Section contracted by Middle Union Railroad bridge.	0.5 of a mile above mouth.	
Bank filled out by Bessemer and Lake Erie Railroad.	0.7 of a mile above mouth,	Extends along creek about 650 feet.
Section contrated by P. R. R. stone arch bridge.	1 mile above mouth.	
Creek walled up by Westinghouse Elec. & Mach. Co. and P. R. R.	Wall begins about 1 mile above mouth at P. R. R. stone arch bridge.	Extends for 3,800 feet to mouth of Thompsons run, both sides being walled in for most of distance.
Low dams at the Westinghouse Elec. & Mach. Co.	East Pittsburg.	
Large bend cut out by P. R. R. and channel straightened and shortened thereby.	At mouth of Thompsons run.	
Creek walled in at Westinghouse Air Brake Co's plant.	Wilmeridng.	

FLOODS.

Floods have been numerous on this creek, and they have apparently been reaching higher elevations and doing greater damage in recent years. Table No. 43 gives a record of the floods in Turtle creek since 1888, showing the heights reached at different points along its course and the elevations of nearby streets and structures.

TABLE NO. 43.

FLOODS IN TURTLE CREEK.

AUGUST 14TH OR 21ST, 1888.

Borough.	Location.	Elevation of highest water during flood.	Nearby Elevations.
E. Pittsburg,	P. R. R. viaduct over Braddock avenue.	735.00	Elev. of street under arch, 731.3.
Turtle Creek,	Penn ave. and N. Y. & O. Gas Coal Co. R. R.	738.40	
Wilmerding,	Junction of T. C. V. & P. R. R. Co.	742.45	Elev. of track, 744.31. Elev. of track July 7, 1903, 745.22. Elev. of track Jan. 15, 1908, 742.74 on bridge.

JANUARY 8TH, 1895.

Port Perry,	Near pumping station,	733.39	Doorsill of Eng. room, 737.18.
East Pittsburg,	Brinton bridge,	731.32	Elev. of roadway, 733.0.
East Pittsburg,	Braddock ave. at 2d angle above Arbor street.	731.82	
East Pittsburg,	End of iron drain pipe above punch shop of W. E. & Mfg. Co.	732.50	
Wilmerding,	Air Brake ave. and Short st.,	738.20	Top W. A. B. Co's wall along creek, 743.8.

JULY 16TH, 1896.

E. Pittsburg,	Brinton bridge,	733.63	Elev. of roadway, 733.0.
E. Pittsburg,	W. E. & Mfg. Co's punch shop, upper end.	733.60	W. E. & Mfg. Co's creek wall at Cable avenue bridge, 736.3.
Turtle Creek,	Penn ave. and Thompsons run,	736.10	General elev. Penn ave., 736.0. Elev. Penn ave. at run, 739.
Turtle Creek,	Turtle Creek and Wilmerding borough line.	736.20	Air Brake ave. at borough line, 734.3.
Wilmerding,	Air Brake ave. and Short st.,	740.80	
Wilmerding,	Foot of Patton st.,	744.60	
Pitcairn,	In pit of turn table at round house,	756.10	Floor of pit, 752.10.

Floods in Turtle Creek—Continued.

FEBRUARY 23RD, 1897.—BACK WATER FLOOD.

Borough.	Location.	Elevation of highest water during flood.	Nearby Elevations.
Port Perry,	Pump station at 10.30 P. M.,	738.56	Highest water recorded up to this time. Highest previous record, 735.68, in Feb., 1884.
E. Pittsburg,	Brinton bridge,	738.59	Elev. road, 733.0.
E. Pittsburg,	Cable avenue,	738.44	Elev. creek wall, 736.30.
Turtle Creek,	Penn avenue and Thompsons run,	738.57	Gen. elev. Penn ave., 736.0.
Wilmerding,	Air Brake avenue and 3d street,	738.69	Top of paving in gutter, 738.68.
Wilmerding,	W. A. B. Co's lumber shed,	738.69	Bed of creek, 729.0.

MARCH 23RD, 1898.

E. Pittsburg,	Upper Union R. R. bridge, 9.30 A. M.,	729.0	
E. Pittsburg,	Old B. & O. bridge, 9.30 A. M.,	729.8	
E. Pittsburg,	Brinton bridge, 8.30 A. M.,	732.08	Elev. road, 733.0.
E. Pittsburg,	Cable avenue,	732.67	Elev. top creek wall, 736.3.
Turtle Creek,	Old mouth of Thompsons run,	734.23	
Wilmerding,	Lower end of W. A. B. Co's carpenter shop.	738.71	Doorsill carpenter shop, 743.9.
Pitcairn,	Highway bridge to Pitcairn Sta.,	755.90	Floor of bridge, 764.02.

AUGUST 19TH, 1898.

Port perry,	B. & O. R. R. bridge,	713.50	Elev. of tracks under bridge, 730.5.
Port Perry,	Tunnel bridge,	717.88	Elev. of floor, 726.55.
E. Pittsburg,	Old B. & O. R. R. bridge,	723.33	
E. Pittsburg,	Brinton bridge,	726.73	Elev. of street, 733.0.
Turtle Creek,	Thompsons run and Penn avenue,	729.48	
Wilmerding,	West end W. A. B. Co's carpenter shop.	735.84	

APRIL 20TH, 1901.

Turtle Creek,	Old mouth Thompsons run,	737.10	
Wilmerding,	Short street,	742.53	Elev. creek wall, 743.8.
Wilmerding,	Bridge street,	745.06	Top creek wall, 743.8.
Pitcairn,	Highway bridge to station,	757.67	Bridge floor, 763.88.
Pitcairn,	In pit of turn table,	755.70	Floor of pit, 752.10.
Stewart,	T. C. V. R. R. bridge over creek,	765.33	
Stewart,	P. R. R. bridge over Brush creek,	768.00	Top rail, 783.6.

JULY 6TH, 1903.

E. Pittsburg,	Brinton bridge,	732.53	Elev. of street, 733.0.
E. Pittsburg,	Cable avenue,	733.51	Elev. creek wall, 736.3.
Turtle Creek,	Thompsons run and T. C. V. R. R.,	736.05	
Turtle Creek,	Overhead bridge to P. R. R. station,	737.07	
Wilmerding,	T. C. V. R. R. bridge near P. R. R. junction.	741.34	Water level on lower side of bridge was 740.34. One foot back water.
Wilmerding,	Short street,	743.67	Elev. creek wall, 743.8.
Wilmerding,	Opposite east end of W. A. B. shops,	744.98	
Wilmerding,	Foot of Patton street,	746.56	
Pitcairn,	Highway bridge to P. R. R. station,	759.37	Bridge floor, 763.88.
Pitcairn,	In pit of turn table of roundhouse,	755.90	

Floods in Turtle Creek—Continued.

MARCH 3RD, 1904.

Borough.	Location.	Elevation of highest water during flood.	Nearby Elevations.
Port Perry,	P. & L. E. R. R. bridge at mouth,	720.60	
Port Perry,	B. & O. R. R. bridge,	721.00	Elev. track under bridge, 730.5.
Port Perry,	Tunnel bridge,	723.91	Elev. floor, 726.55.
E. Pittsburg,	Upper Union bridge,	729.60	
E. Pittsburg,	P. R. R. stone arch bridge, lower side.	732.88	Water was 0.8 feet higher on upper side. Elev. street under arch, 731.3.
E. Pittsburg,	Brinton bridge, upper side,	734.14	Lower side, 733.60.
E. Pittsburg,	Cable avenue,	736.30	Elev. creek wall, 736.30.
Turtle Creek,	Penn avenue and Thompsons run,	739.19	High water probably from run.
Turtle Creek,	New mouth of Thompsons run,	738.34	
Turtle Creek,	Overhead bridge to P. R. R. station,	738.73	
Wilmerding,	Turtle Creek V. R. R. bridge near junction with P. R. R.	740.60	Elev. track, 742.74.
Wilmerding,	Short street,	743.40	
Wilmerding,	Bridge street,	746.08	
Pitcairn,	Highway bridge to station,	759.28	Bridge floor, 763.88.
Pitcairn,	In turn table pit,	755.02	

MARCH 14TH, 1907.—BACK WATER FLOOD.

Port Perry,	Mouth of Turtle creek,	742.15	Elev. normal pool level, 715.2.
Port Perry,	Tunnel bridge,	742.17	Elev. of floor, 726.55.
Port Perry,	Middle Union bridge,	742.31	Elev. top girder, 741.14.
E. Pittsburg,	P. R. R. stone arch bridge,	742.30	Elev. street under arch, 731.3. Elev. top bridge, 753.55.
E. Pittsburg,	Cable avenue,	742.35	Elev. W. M. Co. floor, 738.5. Top of wall, 736.3.
Turtle Creek,	Penn avenue and Thompsons run,	742.50	
Turtle Creek,	Cor. Braddock and Penn avenues,	742.52	Elev. Penn ave., 736.0.
Turtle Creek,	Grant street,	742.49	Mark on borough building.
Turtle Creek,	Overhead bridge to P. R. R. station,	742.48	Same in Penn ave. opposite bridge.
Wilmerding,	Wall along W. A. B. plant,	743.0	Top wall, 743.8.

The above table shows that since 1888 there have been 10 severe floods in the creek of which those of Feb., 1897, and March, 1907, were caused by back water from the river. They are not confined to the winter and spring as is usual on larger streams, one having come in January, one in February, three in March, one in April, two in July and two in August. In addition to the floods here listed there have been several in Thompson run, and other tributaries which did not occur simultaneously with the Turtle creek floods.

CLASSES OF FLOODS.

A study of each flood of which data was available and of the physical conditions over the watershed led to their classification under three heads.

1. Floods caused entirely by heavy rains and melting snows on Turtle creek drainage basin.
2. Floods in small tributaries of the creek which affect their immediate locality only.
3. Floods caused by back water from the Monongahela river.

CLASS I.

Damaging floods have been caused by excessive run-off from the creek basins alone. Such were the freshets of April 20, 1901, July 6, 1903, March 3, 1904, and the majority of the other floods on this stream. The extensive deforestation of the watershed probably results in a high rate of run-off, while the channel at many points has been so restricted as to be unable to pass the high rate of flow without filling the section to depths which flood territory above.

The flood of March 3, 1904, was caused by rain and melting snow over the watershed of the creek, and reached at Turtle Creek borough an elevation of 738.3, a height about four feet below the back water flood of March 14, 1907. A local flood occurring simultaneously in Thompsons run reached a height in the borough nearly one foot higher than the main creek. This flood put 2.5 to 4 feet of water over Penn avenue and immersed most of the business portion and a considerable part of the residential section of Turtle Creek borough. The water was flush with the top of the wall along the Westinghouse Electric and Machine Co. plant at Cable avenue, East Pittsburg, remaining within this section, indicating that with the creek retained within its banks along this stretch, from 2½ to 4 feet of water may be put over Turtle Creek borough.

The rainfall for five days previous to this flood is given below. The ground was saturated with moisture by the first rains and when the 1.75 inches fell on the 3rd, it passed rapidly off, increasing materially the already high run-off resulting from the steady rains preceding it.

TABLE NO. 44.

Rainfall at Irwin on Brush Creek, February and March, 1904.

Date.	Precipitation in inches.	
February 28th,	.57	Some of this may have fallen as snow and been melted by the rain on the 3d.
February 29th,	.39	
March 1st,	.27	
March 2d,	.00	
March 3d,	1.75	
Total,	2.98	

The Monongahela river at this time reached a maximum stage at Pittsburg on March 5th, of 26.5 ft., elevation 723.7 feet, being 9.3 feet below the maximum of March, 1907. At the time of the highest water in Turtle creek, however, the river at its mouth was at an elevation of 720.5, while at Turtle Creek borough it stood at elevation 738.5, the surface of the flood thus assumed a profile approximately parallel to the creek bottom and showed no influence of back water, except close to the mouth. This indicates that this flood was not caused by back water and that it came previous to the highest water in the river. When the back water from the river did come it caused a much lower stage in the creek than did the flood waters from the creek basin. At this time the United States Government navigation dam crossed the stream above the mouth of the creek, while at the time of the 1907 flood it had been moved to a point a short distance below the creek mouth and caused an elevation of the normal river water level of 7.85 feet above the old pool level.

CLASS 2.

The floods upon tributaries which have occurred several times are due to local "cloudbursts" causing sudden rises in these streams and in the creek. Such floods do not always assume large proportions in the creek itself, but do considerable local damage. They result from the barrenness and steepness of the hills bordering the valley, from which the water rushes off without confining itself to the usual channels, overflowing streets, etc. The chief damage at Wilmerding has been by floods of this class and it seems that certain of the smaller floods at Turtle Creek borough have been of a similar nature, the water coming from Thompsons run. The Westinghouse Electric and Manufacturing Co. has been seriously damaged by floods of this class in Fall Hollow run, a small stream with a drainage area of 2.7 square miles, which passes under the works in an arch culvert. This culvert, which has been somewhat contracted by deposition, proves incapable of passing the required volume of water, causing back water behind it and flooding the works and part of the borough of East Pittsburg. The floods in this run are naturally worse when Turtle creek is high and covers the mouth of the culvert at the retaining wall on the creek bank, retarding the discharge therefrom. The culvert has to be cleared of debris and the deposit of gravel and boulders after nearly every flood.

CLASS 3.

Back water floods are less frequent than those arising from other causes, coming only with extraordinarily high river stages. There have been only two floods of this kind in Turtle creek since 1884, those of February, 1897, and March, 1907.

The greatest flood in Turtle creek valley was that of March 14, 1907, which resulted from back water from the Monongahela river. The records at hand show that this flood was the greatest on that river, higher by 3.5 feet at the mouth of Turtle creek than any preceding flood. It occurred at the time of the great flood at Pittsburg, for which the Monongahela river was largely responsible.

The flood run-off from the creek basin must fortunately have nearly passed by the time of the arrival of the crest of the Monongahela flood at the mouth of the creek, as the slope of the water surface at the maximum stage was only 0.9 feet in the lower two miles, while the slope of the water surface during local floods is 10 feet in this section. Moreover, the creek had but a slight velocity at the time of maximum high water and there were no indications of water backing up behind bridges and other channel obstructions as there would have been had this flood been caused entirely by a large run-off in the creek.

There had been at this time one of Turtle creek's periodic local floods, which had begun to recede on the 13th, but early in the morning of the 14th, it assumed alarming proportions, and reached its maximum height at Turtle Creek borough of 742.5 feet above sea level at 3.30 P. M., this level extending from the creek mouth to and beyond Turtle Creek borough. The back water effect was felt at Wilmerding, but did not rise above 743.8, the elevation of the top of the wall bordering the creek at the Westinghouse Air Brake Works. The creek flood, which came prior to the back water flood, just filled this channel, and the back water held to a like position.

The water rose to a height of from 5 to 8 feet above the streets and floors of the stores in the business section of Turtle Creek borough, 3 to 5 feet over the shops of the Westinghouse Electric and Manufacturing Co., and the Westinghouse Machine Co., at East Pittsburg, both of which works were forced to shut down. The water was 10 feet deep, over some of the streets of East Pittsburg, and 17 feet deep over the street leading from the Port Perry bridge, while other towns and industrial works were submerged to a greater or lesser depth.

The only other back water flood since 1884 was that of February 23rd, 1897. This flood, as seen in table number 9, reached a height 4 feet lower than that of March 14, 1907, reaching a maximum at 10.30 P. M. It came at the time of a flood in the Monongahela river which reached a maximum elevation at the creek mouth of 738.6 the highest water recorded in the Monongahela river at this point up to that time. The highest previous elevation reached was 735.7 in February, 1884.

Similar conditions will prevail while floods in the Monongahela river go unchecked, and if conditions of rainfall, melting snow, etc., should so occur as to cause the maximum rate of run-off from Turtle creek basin to coincide with the arrival of the maximum stage in the river at the creek mouth, worse results must be expected. Fortunately, owing to the relative sizes of the two drainage basins, the maximum rate of run-off in Turtle creek usually passes before the maximum stage in the river reaches the creek mouth.

CONTROL.

CONTROL OF BACK WATER FLOODS.

These floods, due to back water from the river, will keep recurring and perhaps increasing in frequency and height until provision is made for river control, for obviously no improvement in the creek channel would in any way reduce the effect of such floods in Turtle creek valley. To shut them out of Turtle creek valley would require the placing of gates across the stream at its mouth and their regulation would necessitate expert supervision, for as soon as the gates were closed the creek water could find no outlet and must back up. If good judgment were not used in their manipulation, damage exceeding that due to back water from the river might result. Such gates could only be operated in conjunction with storage reservoirs on the creek watershed above, and must be placed in a dam crossing the entire creek valley, rising to at least 45 feet above the present creek bed. The cost of such works would be heavy and their operation would necessitate a constant and high operating expense. These floods are infrequent and it is hoped that before many years some control over the Monongahela river may be effected, so that a heavy expenditure on Turtle creek to guard against Monongahela river floods at this time would seem ill-advised.

FLOODS ON TRIBUTARIES OF TURTLE CREEK.

CONTROL OF LOCAL FLOODS.

As stated above, damage has been done along Turtle creek valley by heavy precipitation concentrated on small areas which run rapidly off the barren hillsides bordering the creek. This damage may in some measure be lessened and one of the first steps should be in this direction.

To relieve the conditions which exist on Fall Hollow run, previously described, the following are suggested.

1. Thorough dredging of the existing culvert would secure the advantage of its full cross section, but to obtain the full benefit of this work, the main creek must also be dredged as outlined later.
2. Flap gates could be provided for all catch basin and manhole openings in the culvert between the mouth and its upper end, which gates, when automatically closed during a flood, would increase the discharge by means of the additional head so obtained.

3. Surveys indicate that a suitable site exists for a reservoir at the forks of the creek about 1½ miles above the mouth, above which lies about 50 per cent. of the basin of the stream. This reservoir might serve the double duty of controlling floods and furnishing an additional gravity water supply, as the water would be of much better quality than that in the creek.

THOMPSON'S RUN

Thompsons run has apparently been a great offender against Turtle Creek borough, and its improvement and control would prove beneficial at that point. The stream, which joins Turtle creek from the north passing directly through the borough and under the main business streets, drains a barren area 16 square miles in extent. Nine bridges cross the stream within the borough and others beyond, some of which are obstructions of a serious character, and the bed of the lower portion of the run has been raised several feet and sewer outlets obstructed by deposits of debris brought down from above. Construction work along its banks over a considerable portion of its course has doubtless increased this deposition. The run flows in a narrow valley until the last quarter of a mile of its course, where in the borough of Turtle Creek, the valley widens. In this lower section the chief trouble occurs, for the water backs up behind certain of the bridges of insufficient cross section placed at sharp bends in the stream, and takes the easiest and most natural and direct course down the streets. This is especially the case when the channel at those points is blocked by ice, logs and floating debris, which gather behind the bridges.

To relieve the above conditions on Thompsons run, the following measures are suggested:

1. Straightening of certain bends, as at the Church street bridge, and the N. Y. and Cleveland Gas & Coal Co. bridge, would increase the flood carrying capacity of the channel.

2. Walling up the channel through this section to join the wall of the Westinghouse Electric Co. at the mouth, or at least placing such walls at points where the run now leaves its banks, would increase the flood carrying capacity, and probably hold the flood waters within the banks.

3. Enlarging bridge openings at several points would remove a considerable factor in the floods in this run. The Westinghouse Interworks deck plate girder bridge, the second from the mouth of the run could be made a through bridge, adding about 4 feet of headroom. The Church street bridge, a borough structure, and the New York and Cleveland Gas and Coal Co. bridge, the next down stream, might advantageously be raised and their spans lengthened in moving them to the new positions necessary if the bends on the stream at this point were straightened as suggested in Number 1. A short

through plate girder bridge of the New York and Cleveland Gas and Coal Company further upstream could advantageously be lengthened to give an increased waterway and in its reconstruction the alignment of the channel could be considerably improved as in the cases above mentioned.

4. Storing the flood waters in reservoirs upon the drainage basin of this stream would be beneficial, but examination failed to disclose a suitable site.

5. Dredging the channel within the borough limits to a proper cross section and a slope descending uniformly to the finished channel of Turtle creek at the mouth, would increase the flood carrying capacity and, combined with the recommendations offered above, would probably retain local floods within the banks. But such a remedy would be only temporary, unless measures were taken to stop further deposition of material in the stream bed above or along its banks, at points where, unless protected, erosion by the flood waters takes place, and to protect the present railroad embankments bordering the stream from erosion by suitable rubble walls or riprap.

Other small streams such as Sawmill Valley run, which joins Turtle creek from the north just above Thompsons run, and several small streams at Wilmerding, which overflow their banks after heavy rains and do considerable damage, can be regulated by similar methods.

CONTROL OF FLOODS IN TURTLE CREEK PROPER.

All but two of the ten floods recorded in table number 9, were in the creek proper, due to rapid run-off from its watershed. A study of the causes leading to these floods indicates that they may be ameliorated by proper works as follows:

1. Straightening the channel at certain points where sharp bends occur will increase the fall and decrease frictional losses. Such a point exists at the Pennsylvania Railroad crossing between Turtle Creek borough and Wilmerding, and another near the mouth just below the Pennsylvania Railroad stone arch bridge. It might be noted that at the mouth of Thompsons run an improvement of this nature has been made.

2. Walling up the banks, particularly at low points and at bends, will increase the discharging capacity of the section and prevent local overflow and washing of banks.

3. Dredging the channel of the creek from about Cable avenue, East Pittsburg, past Turtle Creek toward Wilmerding and squaring up the cross section throughout the length of the creek from its mouth to Trafford City, will increase the capacity of the channel. The channel has been greatly filled in by deposits washed from above so that additional depth of several feet may be so obtained. The low water channel does not show such extensive deposits as does the creek bed on each side thereof. This dredging, in order to be of lasting

benefit, should be accompanied by suitable protection of the railroad embankments along its shores, where liable to erosion, and the discontinuance of works higher up on the creek, the washings from which would deposit below.

4. By constructing storage reservoirs on Turtle creek and Brush creek near Trafford City for retaining flood waters, the discharge during floods may be so regulated as to decrease damage below through water backing up behind contractions of the channel and consequent overflow.

Computations of the flood discharge when the creek channel is flowing full to such a height as not to overflow its banks, indicate that at such height all reduced sections and all bridge openings, except the P. R. R. stone arch bridge and the Middle Union Railroad bridge, will carry a flood representing a flow at a rate of 50 second-feet per square mile. The flood of March 3rd, 1904, with its estimated maximum rate of discharge 64 second-feet per square mile, could not be carried by the creek channel at several points, its profile showing that the water backed up above the Brinton bridge and the Pennsylvania Railroad stone arch bridge, and also that in order for flood waters to be carried by the walled-in channel along the Westinghouse works at East Pittsburg it was necessary to fill that channel to such a height as to submerge streets in a neighboring towns. Data with reference to Neshaminy creek, watershed 152 square miles, 6 per cent. forests, indicate that a maximum rate of discharge of 140 second-feet per square mile might under extraordinary conditions be expected. Several of the obstructions mentioned above are of a substantial character and expensive to alter, while others can be more readily changed to allow of an increased section. The reservoir suggested above should be designed to hold all flood water over and above a discharge of 50 second-feet per square mile, but the calculation of capacity of sections below involves the straightening, walling and dredging outlined above.

Near Trafford City, reservoirs could be formed by dams or embankments, 20 to 25 feet above the creek bed, one about 100 feet long on Brush creek and a much longer one on Turtle creek, a few hundred feet above their junction. Back water would extend up Brush creek about 1½ miles and up Turtle creek about one mile. Each reservoir, when full, would flood about 125 acres, and the combined capacity would approximate 150 million cubic feet. The area required for these reservoirs is partly barren unused land and partly under cultivation, with perhaps half a dozen small houses upon it. The Pennsylvania Railroad crosses the site of the Brush creek reservoir at an elevation above the proposed water surface. These reservoirs are estimated to hold the surplus between the allowable discharge of 50 second-feet per square mile and the possible extraordinary flow of 140 second-feet if this rate was maintained about four hours. The maximum rate in the 1904 flood is computed to have reached 64 second-feet per square mile so that these proposed reservoirs could have retained the surplus 14 second-feet per square mile had it continued for about 25 hours. It may be expected that the channel improvements to the main creek and its lower tributaries would enable the floods in Thompsons run, Fall Hollow run, etc., to be exhausted before a high rate of run-off reached Turtle Creek borough from above Trafford City.

Table No. 45, shows the allowable heights of floods at various points along the creek, *i. e.,* the height at which it is believed no overflow would occur when the improvements suggested have been made. The slope of the surface is approximately that which would result from a flood within these allowable proportions.

TABLE NO. 45.

Allowable Flood Heights.

Location.	Elevation above sea level.
East line Turtle Creek borough,	740.0
Mouth of Thompsons run,	735.0
Cable avenue, East Pittsburg,	732.5
P. R. R. stone arch bridge,	729.1
Upper Union bridge,	726.5
Middle Union bridge,	725.0
Tunnel bridge,	723.5
B. & O. R. R. bridge,	721.0
Mouth,	720.0

In compiling this table the elevation 720 at the mouth of Turtle creek has been assumed, as that of an ordinary high stage in the Monongahela river during the spring or freshet season. The pool level is five feet lower than this and when floods in the creek occur with a lower stage in the river than 720 an additional slope is available and a greater discharge can be passed. This effect is noticed in comparing floods of approximately equal size on the Monongahela river, one occurring when the Allegheny is in flood, and the other when there is no flood on that river. In the former case there is less slope on the Monongahela river and consequently a higher crest. If the navigation dam had not been moved from above, to below the mouth of the creek, this allowable elevation instead of being 720 could have been 713, giving an additional 7 feet of slope in the lower section of the creek where several bridges of small cross section cause obstructions.

Assuming elevation 740 at the upper end of the borough of Turtle Creek, will probably necessitate raising the low portion of Air Brake avenue six feet as well as certain low lands occupied by several houses bordering the creek. Air Brake avenue is lower in the upper part of the borough than in the business section, where it is known as Penn avenue, and floods overflow the creek bank at this point, following this street into the town. This land might be elevated with the material dredged from the creek channel.

The Pennsylvania Railroad stone arch bridge apparently did not pass the flood of 1904 and computations fail to show at the elevation shown a section sufficient to pass the allowable 50 second-feet per square mile, but by using the third arch for flood waters and placing the railroads tracks which pass under this arch on a trestle, this section can be made large enough. The Middle Union Railroad bridge has an opening but 58 feet wide and it should be widened 10 feet. When filled to the allowable section it now passes but 36 second-feet per square mile.

Owing to the comparative sizes of the catchment areas of the Monongahela river and Turtle creek, the floods in this creek may be expected to be, and usually are, discharged before very high stages in the river reach the creek mouth, but it is quite possible, under the present conditions, for a creek flood to be coincident with a back water flood from the river, as it is only necessary in order to cause this condition, to have rains on the Turtle creek basin occur a day or two subsequent to those on the Upper Monongahela and Youghiogheny river basins. As under such circumstances worse floods than any hitherto experienced might be expected, it is essential to be able to control the creek floods, passing the water out ahead of the river flood; or, when necessary, retarding them, to pass out after the crest of the river flood has passed the creek mouth. Straightening the channel, dredging, walling and the removal of obstructions suggested above will do much to hasten the discharge of creek floods, and when conditions of later rainfall take place on Turtle creek, the floods so caused can be retarded by the proposed reservoirs at Trafford City.

EFFECT OF CHANGE OF NAVIGATION DAM.

When floods in the river assume such proportions as to cause back water up the creek as far as East Pittsburg and Turtle Creek borough, the flood section in the river is much increased and probably little influenced by the dams. This is shown by profiles of various floods, which indicate less and less of an interruption to a straight line at the dams, as the floods increase in height.

TABLE NO. 46.

Apparent Effect of Navigation Dam No. 2 on Monongahela River upon Floods in That River.

Date of Flood.	Elevation of water upper side of dam.	Elevation of water lower side of dam.	Drop in water surface at dam.
Normal pool level,	715.25	707.4	7.85
February 14, 1900,	722.5	719.0	3.5
May 17, 1898,	724.0	721.5	2.5
March 29, 1899,	725.4	724.6	0.8
November 26, 1900,	733.2	732.7	0.5
February 24, 1897,	738.4	738.4	0.0

From studies of floods on the Monongahela river it does not appear that because the pool level at the mouth of Turtle creek has been raised 7.83 feet the phenomenal freshets on that stream are or will be appreciably higher at that point. In any considerable flood the amount of the additional rise in the water surface at the mouth of Turtle creek, due to the relocation of Dam No. 2, is in fact very small, being dependent upon the flood slope, which, during phenomenal freshets, is less than one foot per mile.

This change in the Monongahela pool level, however, affects the local creek floods, for at ordinary pool level the slope of the creek is reduced 7.85 feet, materially decreasing its carrying capacity. Floods in the creek which occur when the river is normal are thus hindered in their discharge and this element has had to be considered in determining the safe flood elevations and computing the allowable discharge. There may be floods in Turtle creek, occurring when the river is at fairly high but not extraordinary stage, which will do more damage and rise to higher elevations along the creek by reason of this elevation of the pool level. The change in the location of the dam also causes increased deposition along the lower portion of the creek bed, which, near its mouth, has since 1904 apparently filled up several feet.

The citizens of Turtle Creek borough have seriously considered seeking relief from flood damage by raising the town, and the borough engineer has made plans and estimates showing that at a cost of about $150,000 the streets could be raised 10 feet, but other work which must be carried out in connection with this improvement would very materially increase this figure, while the relief effected would be purely local, and the cost would probably exceed that of the recommendations for general relief herein made. In the methods of relief suggested in this report, no provision is made for protection against back water floods, which would be guarded against by raising the town, but it is probable that before many years measures will be taken for the reduction of floods in the Monongahela river. It is only the highest floods in the river which cause these back water floods in the creek. Only two such have occurred in 23 years and the Monongahela river may be under partial control before conditions again exist which would cause another.

It is believed that money would be most wisely spent in preventing damage throughout the valley by the frequent floods local to the creek, and it is hoped that the communities and industries along this stream will unite in a system of general relief.

There is a possibility that the several communities in the lower portion of the valley of this creek will combine in a sewerage system and disposal plant, which, I am informed, would include an intercepting sewer following the creek to its mouth. Similar united action could be taken toward the flood control works suggested, bringing together the boroughs of Pitcairn, Wilmerding, Wall, Turtle Creek, East Pittsburg and North Braddock together with the Westinghouse Electric and Machine and Air Brake Companies and other industrial corporations in the valley, and the several railroad companies whose tracks traverse the valley.

Respectfully submitted,

FARLEY GANNETT, *Engineer.*

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